SAINT JOHN RIVER BASIN
Limestone, Maine

LIMESTONE DAM
ME 00492

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
Waltham, Mass. 02154

SEPTEMBER 1981

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254

REPLY TO
ATTENTION OF:
NEDED

SEP 16 1981

Honorable Joseph E. Brennan
Governor of the State of Maine
State Capitol
Augusta, Maine 04330

Dear Governor Brennan:

Inclosed is a copy of the Limestone Dam (ME-00492) Phase I Inspection Report, prepared under the National Program for Inspection of Non-Federal Dams. This report is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. I approve the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is vitally important.

Copies of this report have been forwarded to the Department of Agriculture and to the owner, Town of Limestone. Copies will be available to the public in thirty days.

I wish to thank you and the Department of Agriculture for your cooperation in in this program.

Sincerely,

C. E. Edgar III

C. E. EDGAR, III
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ME 00492	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Limestone Dam NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS		5. TYPE OF REPORT & PERIOD COVERED INSPECTION REPORT
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS DEPT. OF THE ARMY, CORPS OF ENGINEERS NEW ENGLAND DIVISION, NEDED 424 TRAPELO ROAD, WALTHAM, MA. 02254		12. REPORT DATE September 1981
		13. NUMBER OF PAGES 60
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVAL FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,
Saint John River Basin
Limestone, Maine
Limestone Stream

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The dam is about 300 ft. long, 19 ft. high, and 9 ft. wide at the crest. The dam is rated fair because the spillway can not pass the test flood. It is small in size with a high hazard potential. No urgent or emergency actions are required for Limestone Community Dam based on this inspection.

[LIMESTONE COMMUNITY DAM, Limestone...]

ME 00492

ST. JOHN RIVER BASIN
LIMESTONE, MAINE

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM

PHASE I INSPECTION REPORT

Identification No.	:	ME 00492
Name of Dam	:	Limestone Community Dam
Town	:	Limestone
County & State	:	Aroostook, Maine
Stream	:	Limestone Stream
Date of Inspection	:	November 6, 1979

BRIEF ASSESSMENT

Limestone Community Dam is a dual purpose recreation and flood water retarding structure. It is an earthfill structure with a slurry wall cutoff trench. The spillway is a concrete paved, broad crested weir and chute that discharges into a stilling basin. The flow over the weir is uncontrolled. The embankment is approximately 300 feet long, 19 feet high and 9 feet wide at the crest. A 36" diameter low level outlet allows the reservoir to be drained to Elev. 516.5 NGVD. The normal depth of the reservoir is approximately 20 feet. A fishway is located immediately to the right of the spillway chute. The original earthfill embankment structure had a gabion and timber covered spillway which was damaged prior to 1977. Repair of the structure was designed and performed in 1977. That same year, heavy flows again washed out the gabion covered spillway. In 1978, a concrete slab spillway surface was designed and constructed to replace the former gabion covered spillway. A recreation pool is maintained behind the pool at Elev. 526.5.

The embankment dam, outlet works, central spillway chute, concrete training walls and fishway were found in good condition. In the earthfill embankment itself, there were no dips, sags or other evidence of distress. The concrete structures including the broad crested weir spillway were sound with no visible evidence of deterioration. The grass cover on the embankment was well established. The rip-rap on both the downstream and upstream faces was in good condition. The dam is rated fair because the spillway can not pass the test flood.

Based on a maximum storage of approximately 130 acre-feet and a height of 19 feet, Limestone Community Dam is clasified as small. The dam's hazard classification has been established as high based on the potential for loss of more than a few lives in the event of a dam failure. The test flood was the 1/2 PMF and was estimated for the 27.9 square mile drainage area of rolling terrain using the "Preliminary Guidance for Estimating Maximum Probable Discharges in Phase I Safety Investigations", New England Division Corps of Engineers, March 1978. This yielded a peak inflow of 12890 cfs and a routed outflow of 12770 cfs. The spillway has a capacity of 7150 cfs which is 56% of the test flood outflow. The computed maximum reservoir level El. 536.2 was above the embankment crest El. 534 and overtopping of the embankment would occur.

No urgent or emergency actions are required for Limestone Community Dam based on this inspection. Remedial measures include developing a downstream warning system and conducting bi-annual technical inspections of the dam. It is also recommended that a second, more detailed hydrological study be performed on this dam to determine what effect flood routing through the two upstream dams would have on the performance of Limestone Community Dam.

J.E. Giles, Jr., P.E.
Project Manager
Massachusetts Registration No. 1643

This Phase I Inspection Report on Limestone Dam (ME-00492) has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgement and practice, and is hereby submitted for approval.

JW Finegan

JOSEPH W. FINEGAN, JR. MEMBER
Water Control Branch
Engineering Division

Aramast Mahtesian

ARAMAST MAHTESIAN, MEMBER
Geotechmical Engineering Branch
Engineering Division

Carney M. Terzian

CARNEY M. TERZIAN, CHAIRMAN
Design Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Fryar

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of Phase I investigation: however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservior was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

The Phase I Investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project compliance with OSHA rules and regulations is also excluded.

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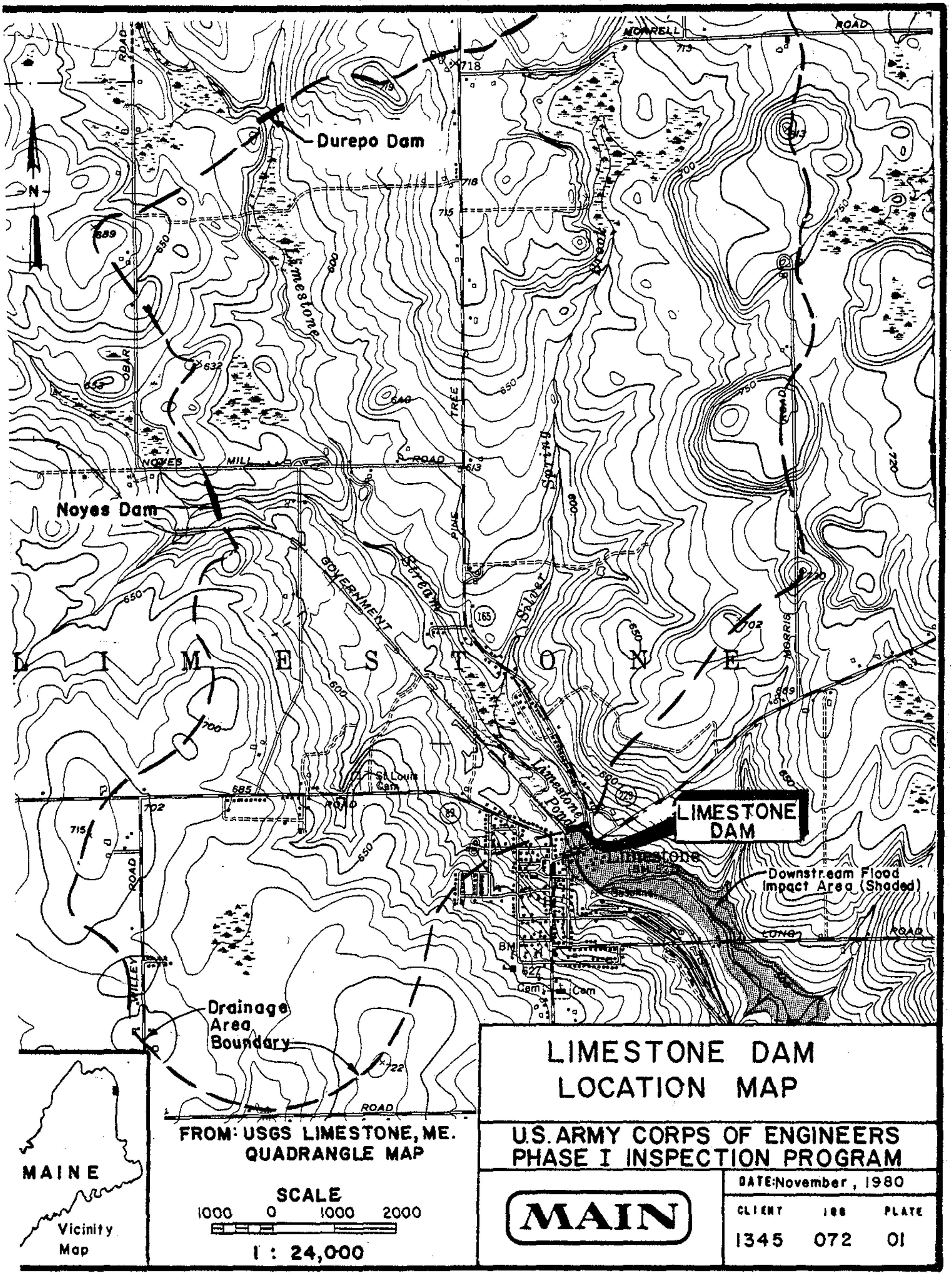
LIMESTONE COMMUNITY DAM

VIEW FROM BRIDGE BELOW DAM

Approx. 0.2 sq. mi. of Drainage Area not shown on map.



NATIONAL DAM INSPECTION PROGRAM

PHASE I INSPECTION REPORT

LIMESTONE DAM, LIMESTONE MAINE

SECTION I

PROJECT INFORMATION

1.1 General

a. Authority - Public Law 92-367, August 8, 1972 authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Chas. T. Main, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Maine. Authorization and notice to proceed were issued to Chas. T. Main, Inc. under a letter of November 6, 1979 from Max B. Scheider, Colonel, Corps of Engineers. Contract No. DACW 33-80-C-0011 has been assigned by the Corps of Engineers for this work.

b. Purpose

(1) The purposes of the inspection program are: To perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

(2) To encourage and prepare the states to initiate effective dam safety programs for non-Federal dams.

(3) To update, verify and complete the National Inventory of Dams.

c. Scope of Inspection Program - The scope of this Phase I inspection report includes:

(1) Gathering, reviewing and presenting all available data as can be obtained from the owners, previous owners, the state and other associated parties.

(2) A field inspection of the facility detailing the visual condition of the dam, embankments and appurtenant structures.

(3) Computations concerning the hydraulics and hydrology of the facility and its relationship to the calculated flood through the existing spillway.

(4) An assessment of the condition of the facility and corrective measures required.

It should be noted that this report does not pass judgment on the safety or stability of the dam other than on a visual basis. The inspection is to identify those features of the dam which need corrective action and/or further study.

1.2 Description of Project

a. Location - The Limestone Community Dam is located on Limestone Stream in the Town of Limestone, Aroostook County, Maine. The dam location is included on U.S.G.S. 7.5 minute series Quadrangle, Limestone, Maine with approximate coordinates N46°45'45", W67°49'30".

b. Description of Dam and Appurtenances - The project consists of three principal features: an earthfill dam, a spillway chute, and a fishway. The dam embankment is approximately 300 feet long and 19 feet high. The original dam had approximately the same dimensions. (Design and construction details of the original structure were not available.) The reconstructed structure used the original dam earthfill embankment and filled in the areas which had washed out with new fill. The fill materials are of glacial till origin with zoning limited to placing the more impervious material in the core and the more pervious material in the outside shells. The structure has an approximate 2' x 9' slurry trench below the core.

The spillway is an uncontrolled broad crested weir and chute with crest Elev. 526.5 NGVD. The spillway surface is a concrete slab. This concrete structure replaces the previous gabion covered spillway which was washed out during high flows. The upstream and downstream slopes at the spillway are approximately 1 vertical to 2.5 horizontal. The sides of the spillway are vertical reinforced concrete training walls. The adjacent left and right embankments are grass covered. The fishway runs adjacent to the right spillway training wall with gravel fill separating the two. The dam is equipped with a 36" RCP reservoir drain located to the right of the spillway. The drain is controlled by a sluice gate that operates inside the 6' diameter concrete riser on the right embankment.

Plans, profiles, and sections of the dam and its appurtenent structures are included in Appendix B. Photographs are shown in Appendix C.

c. Size Classification - The maximum embankment height is 19 feet above the stream channel and the maximum storage is 140 acre feet at El. 534.0. This gives the dam a small size classification (since the storage is greater than 50 and less than 1,000 acre-feet) in accordance with the Recommended Guidelines for Safety Inspection of Dams.

d. Hazard Classification - This facility is classified as a high hazard potential dam based on the potential for loss of more than a few lives in the event of a dam failure in eleven occupied dwellings downstream of the dam.

e. Ownership - The dam and associated works are owned by the Town of Limestone, Maine.

f. Operators - The project is designed for unsupervised operation. No manual operations are required to pass a flood flow. The project is operated and maintained by the Town of Limestone, Maine. The responsible person is Mr. Thomas Stevens, Town Manager, Limestone, Maine 04750, Telephone (207) 325-3131. (The Town Manager at the time of this inspection was Mr. Peerless J. Snow.)

g. Purpose of Dam - The project is a flood water retarding and recreational facility. The reservoir drain intake sluice gate is currently closed and the reservoir maintained at El. 526.5 for fish and recreation purposes.

h. Design and Construction History - Design and construction data concerning the original structure was not available. It is known that the original dam was similar to the existing structure except that it had wood timber training walls adjacent to the spillway and a combination of gabion/wood timber spillway surface rather than reinforced concrete. This dam was damaged during flood flows prior to 1977. The damage consisted primarily of a washout of the central spillway section. Rehabilitation of the structure was designed and performed in 1977 by Edward C. Jordan Company, Inc. from Presque Isle, Maine. During the same year the dam was again damaged by high flows. The following year, 1978, a federally assisted contract, "Rehabilitation of Community Dam, Heritage Conservation and Recreational Service, Project No. 23-00303" resulted in the present structure, completed in 1978. The design and repair work was by E.C. Jordan Co., Inc.

i. Normal Operating Procedures - The reservoir is normally maintained at El. 526.5 for recreation purposes. All flood flows are passed through the spillway chute which is designed for uncontrolled discharge. No other operating procedures are in evidence.

1.3 Pertinent Data

a. Drainage Area - Limestone Community Dam controls a drainage area of 27.9 square miles. The watershed is approximately 65 percent wooded and 35 percent agricultural. There are two dams upstream; Noyes Brook Dam, D.A. of 2.85 square miles, and Durepo Brook Dam, D.A. of 20.03 square miles.

b. Discharge at Damsite

(1) Outlet Works - The spillway is a broad crested weir at elevation 526.5 with a reinforced concrete deck. The weir is 116 feet wide. A sluice gate and 36"Ø RCP provide the capability to drain the reservoir to El. 516.5.

(2) Maximum known flood - Unknown.

(3) Spillway capacity at top of dam - 7150 cfs @ El. 534.0.

(4) Spillway capacity at test flood elev. - 10550 cfs @ El. 536.2.

(5) Gated spillway capacity at normal pond elevation - N/A.

(6) Gated spillway capacity at test flood elevation - N/A.

(7) Total project discharge at top of dam - 7150 cfs @ El. 534.

(8) Total project discharge at test flood elevation - 12773 cfs @ El. 536.2.

c. Elevations (feet above NGVD)

(1) Streambed at toe of dam	515.0
(2) Bottom of cutoff	502.0
(3) Maximum tailwater	Not available
(4) Normal pool	526.5
(5) Full flood control pool	N/A
(6) Spillway crest	526.5
(7) Design surcharge (Original Design)	Not available
(8) Top of dam	534.0
(9) Test flood surcharge	536.2

d. Reservoir (Length in feet)

(1)	Normal pool	1400
(2)	Flood control pool	N/A
(3)	Spillway crest pool	1400
(4)	Top of dam	2900
(5)	Test flood pool	3300

e. Storage (acre-feet)

(1)	Normal pool	40
(2)	Flood control pool	N/A
(3)	Spillway crest pool	40
(4)	Top of dam	142
(5)	Test flood pool	207

f. Reservoir Surface (acres)

(1)	Recreation pool	8
(2)	Flood-control pool	N/A
(3)	Spillway crest	8
(4)	Test flood pool	34
(5)	Top of dam	24

g. Dam

(1)	Type	Earthfill
(2)	Length	300 feet
(3)	Height	19 feet
(4)	Top Width	9 feet
(5)	Side Slopes	Upstream 2.5 Hor. to 1 Vert. Downstream 2.5 Hor. to 1 Vert.

(6)	Zoning	2 zones
(7)	Impervious Core	Most impervious toward the core
(8)	Cutoff	2' x 9' slurry wall
(9)	Grout curtain	N/A
(10	Other	N/A

h. Diversion and Regulating Tunnel

(1)	Type	N/A
(2)	Length	N/A
(3)	Closure	N/A
(4)	Access	N/A
(5)	Regulating Facilities	N/A

i. Spillway (Principal)

(1) Type - Broad crested weir with reinforced concrete deck

(2) Length of weir - 116 feet

(3) Crest elevation - 526.5

(4) Gates - N/A

(5) U/S Channel - N/A

(6) D/S Channel - Natural

(7) General - Reinforced concrete vertical training walls along both sides of spillway.

j. Regulating Outlets

(1) Invert - El. 516.5

(2) Size - 36" Dia. RCP

(3) Description - Sluice gate to drain reservoir

(4) Control Mechanism - 36" ϕ Sluice gate w/screw operator

(5) Other - None

SECTION 2

ENGINEERING DATA

2.1 Design

Information concerning the original design of the dam (prior to 1958) was unavailable. The reconstruction of the dam in 1977 was designed by the Edward C. Jordan Company, Inc., of Presque Isle, Maine. The latest rehabilitation of the structure (1978) was again designed by the E.C. Jordan Company. The design calculations used by this Company were unavailable to the inspection team. The construction drawings for both the "reconstruction" (1977) and "rehabilitation" (1978) were given to the inspection team by the Limestone Town Manager.

2.2 Construction

No construction records or photographs were available to the inspection team. A set of construction prints was reviewed. Those pertinent to this report are included in Appendix B. The drawings titled "Reconstruction of Community Dam" are those used for the earlier repair work (1977). The drawings titled "Rehabilitation of Community Dam" are those used for the later (existing) repair work (1978).

2.3 Operation

No formal operational procedures were available for review. The spillway is an uncontrolled structure requiring no manual operations.

2.4 Evaluation

a. Availability: No design calculations were available to the inspection team. A set of General Contract Specifications for the latest repair work (1978) of the structure was reviewed.

b. Adequacy: The lack of design calculations did not allow for a definitive review. Evaluation must be based on visual inspection, past performance history, and sound engineering judgment and experience.

c. Validity: The limited data available restrict evaluation of the Limestone Community Dam and appurtenances to the visual inspection and sound engineering judgment. The field inspection indicated that the external features of Limestone Community Dam substantially agree with those shown on the available plans.

SECTION 3

VISUAL INSPECTION

3.1 Findings

a. General - The field inspection was conducted by L. Seward and J. Jonas of Chas. T. Main, Inc. on 6 November 1979, and J. E. Giles, Jr. on August 12, 1981. On the date of inspection, the Limestone Community dam and appurtenances were in good condition. No urgent or emergency actions are required at this time.

b. Dam

(1) Crest - The embankment crest was true to line with no apparent dips, sags, cracks or other evidence of distress (Photo 6). The as-built camber was observed and appears unchanged. The crest is grass covered with no pavement.

(2) Upstream slopes - The upstream slope riprap appeared in good condition. The slopes above the normal pool El. 526.5 have a well developed tight grass cover (Photo 4). There was no evidence of sloughing or erosion on the slopes.

(3) Downstream slopes - The downstream slope rip-rap appeared in good condition. The slopes have well developed, tight grass covers. No significant gully action was observed on the slopes (Photos 5 and 6). No slides or sags were observed.

(4) Downstream toe - The downstream toe is generally dry with no boils or seeps observed.

(5) Underdrain system - None.

(6) Instrumentation - No instrumentation was observed.

c. Appurtenent Structures

(1) Spillway - The broad crested weir spillway and chute were in good condition (Photo 5). The adjacent reinforced concrete training walls were also in good shape with no visible deterioration.

(2) Fishway - The fishway appeared in good condition. The downstream fishway inlet is located on the right side of the spillway chute.

(3) The outlet works were not accessible. The visible portion of the circular concrete riser appeared in good condition.

d. Reservoir Area - No areas of potential or actual shoreline movement were observed (Photo 3).

e. Downstream Channel - Approximately 200 yards downstream, Limestone Stream flows under Highway 229. The opening in the bridge is approximately 7' x 29'.

3.2 Evaluation - In general, the dam and appurtenances are in good condition. The short abutment slopes are stable and in good shape. The concrete structures are sound. No urgent or emergency repairs are required.

SECTION 4

OPERATIONAL AND MAINTENANCE PROCEDURES

4.1 Operational Procedures

a. General: The spillway is an uncontrolled crest structure. No manual operations are required to insure safe passage of a flood flow. No recent operation of the reservoir drain is reported.

b. Description of Downstream Warning System: No warning system or emergency evacuation plans are in effect for this project.

4.2 Maintenance Procedures

a. General: No regular maintenance procedures are in effect for this project.

b. Operating Facilities: There are no manual operating facilities at this structure except for the reservoir drain gate. No regular maintenance procedures for the project operating facilities are specified.

4.3 Evaluation

The operating and maintenance procedures are limited for this project. The owner should establish procedures to inspect the structures regularly, to continue to keep the embankment free of brush and trees, and to monitor the level of the reservoir during periods of intense rainfall.

The owner should arrange to have a technical inspection made on a bi-annual basis. The owner should establish a downstream warning system to follow in the event of emergency conditions.

SECTION 5

EVALUATION OF HYDROLOGIC AND HYDRAULIC FEATURES

5.1 General - The watershed is 27.9 square miles of rolling terrain. The dam is located on the Limestone Stream in the Town of Limestone. The earth embankment develops sufficient storage to reduce the peak from 12890 cfs to 12773 cfs (about 1% reduction). The Durepo Brook (D.A. of 20 sq. mi) and the Noyes Brook (D.A. of 3 sq. mi.) Dams are inside the drainage area of the Limestone Community Dam, and they are part of the S.C.S. Limestone Watershed Work Plan.

5.2 Design Data - The dam was designed and constructed by the Edward C. Jordan Company Inc. from Presque Isle, Maine. The concrete section of the dam is in the form of a broad crested weir with a width of 116 feet and a crest elevation of 526.5 feet. The channel sides are formed by the vertical concrete walls that extend to Elev. 534. The dam embankment has the same top elevation of 534 feet. The reservoir drain system consists of a six foot diameter precast concrete riser with a reservoir drain inlet of reinforced concrete located about 300 feet upstream of the dam, a 36 inch inlet pipe with an invert elevation of 516.5 feet and an outlet downstream of the spillway apron. The upstream and downstream slopes of the spillway are approximately 1 vertical to 2.5 horizontal.

5.3 Experience Data - It is known that heavy flows in the past have seriously damaged the dam at least twice; once prior to 1977 and once in 1977. The magnitude of these flows was unavailable.

5.4 Test Flood Analysis - Based upon "Preliminary Guidance for Estimating Maximum Probable Discharge", dated March 1978, the watershed classification (rolling), the PMF is estimated to be equivelent to 25,770 cfs. (921 csm). For this portion of Maine the Maximum Probable Runnoff is assumed to be 13 inches. Upstream, the Durepo Brook and the Noyes Brook reservoirs control more than 80 percent of the drainage area. By considering the flood reducing effects of these reservoirs the test flood for this high hazard, small size dam is selected to be equivalent to the 1/2 PMF or 12,890 cfs (460 csm).

In our hydraulic computations, the flood routing starting elevation was the spillway crest elevation 526.5 NGVD. The routed test flood outflow was determined in accordance with Corps of Engineers "Guidance for Estimating Effect of Surcharge Storage on Maximum Probable Discharges", and the hydraulic characteristics of the dam. Spillway discharge was computed as flow over a weir. The routed test flood outflow was determined to be approximately 12770 cfs, (about one percent reduction), and corresponding water surface elevation 536.2 ft. The top of the dam is at elevation 534.0 ft and thus the dam would be overtopped by 2.2 ft. The spillway capacity of 7150 cfs is about 56 percent of the test flood.

5.5 Dam Failure Analysis - The dam failure was assessed using the "Rule of Thumb Guidance for Estimating Downstream Dam Failure Hydrographs" prepared by the Corps of Engineers. The reservoir water level was assumed at the top of the dam prior to the breach event. The flooding damage was first analyzed for prefailure condition by considering a discharge from the dam equal to the spillway capacity, 7150 cfs. The water depths in the river due to this flood were calculated to be approximately 11 feet. About 14 houses 500-1000 feet downstream are located 5 to 10 feet above the stream bed. These houses and the bridge on the road of 229 will be damaged during this prefailure flood.

The additional flood discharge due to breaching of the dam was calculated to be 15600 cfs. In these calculations the reservoir volume prior to failure is 142 ac-ft, the breach height is 19 ft, and the breach width is 112 ft. Immediately downstream after the failure the total discharge becomes 22750 cfs with a depth of 16.8 ft. In this case the spillway becomes submerged and the decrease of its discharge is estimated to be 6 percent. The new spillway discharge of 6718 cfs together with routed breach discharges was considered in calculating the downstream water depths. The calculations (see Appendix D) showed that water depths will be 15.9 - 15.3 ft. and an additional 3 houses (previously unflooded) located 500 - 100 ft. downstream will be impacted by approximately 5-7 feet of water.

A second breach study was performed to evaluate the failure effect in dry conditions. In this case water levels were assumed at spillway crest elevation. The height of the breach was 11.5 ft. and the width 170 ft. The breach discharge was 3900 cfs. This was routed downstream. The calculations results show that about 11 houses will be flooded with water to depths of approximately three feet.

From these studies it is concluded that this dam should be classified as having a high hazard potential because more than a few lives could be lost in the event of a dam breach. Furthermore, it is shown that about fourteen homes are presently located in the flood plain area and will be damaged during a breach event.

SECTION 6

EVALUATION OF STRUCTURAL STABILITY

6.1 Visual Observation

The visual inspection of November 6, 1979 revealed no dips, sags, depressions or other evidence of instability. Nothing was noted that would indicate that the dam structure is unstable.

6.2 Design and Construction Data

Design calculations and construction records were not available for review in preparing this report. The construction drawings for the dam repair work were reviewed.

6.3 Post Construction Changes

No evidence of modification to the dam since the rehabilitation of the dam in 1978 was observed.

6.4 Seismic Stability

The dam is located in Seismic Zone No. 2 and, in accordance with recommended Phase I guidelines, does not warrant seismic analysis.

SECTION 7

ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition - This inspection indicates that the Limestone Community Dam is in good condition but is rated as fair because of the inadequacy of the spillway to pass the test flood. The inspection found the following:
(1) There are approximately fourteen homes located in the flood plain immediately downstream. These will be damaged by a flow equal to the capacity of the spillway (or when the water level is at the top of the dam).

(2) The spillway capacity is 7150 cfs which is approximately 56 percent of the Test Flood outflow (1/2 PMF).

(3) The appearance of the concrete spillway and adjacent earthfill embankments is good.

b. Adequacy of Information - The lack of in-depth engineering data did not allow for a definitive review of this dam. Therefore, the adequacy of the dam could not be assessed from the standpoint of reviewing design and construction data but is based solely on visual inspection and engineering judgment.

c. Urgency - The remedial measures presented below should be implemented by the Owner within one year of receipt of this Report.

7.2 Recommendations

Because of the location of this dam in a densely populated area and the results of the Dam Failure Analyses it is recommended that a second, more detailed hydrological study be performed for this dam. This study should take into consideration the reducing effects of the upstream (Durepo Brook and Noyes Brook) dams during flood flows as well as the effect that the Route 229 bridge immediately downstream will have.

7.3 Remedial Measures The owner should:

a. Develop a downstream warning plan to be used in the event of an emergency at the dam.

b. Establish a system to monitor the project during periods of intense rainfall.

c. Implement a monthly visual inspection program of the dam and appurtenances. Observations should be recorded in a maintenance log.

d. Conduct bi-annual technical investigations of the project.

e. Establish regular maintenance procedures and continue to keep the embankments well-groomed and free of brush and trees.

f. Insure the operability of the reservoir drain.

g. Obtain and maintain a readily accessible set of as-built drawings and technical investigation reports.

APPENDIX A

FIELD INSPECTION CHECK LIST

INSPECTION CHECKLIST

PARTY ORGANIZATION

ROJECT Limestone Community Dam

DATE Nov. 8, 1979

TIME 9:30

WEATHER Fair-Sunny - $40^{\circ}F$

U.S. ELEV. ________ U.S. ____ DN.S.

ARTY:

. Lewis B. Seward - Hydrologist 6. ________

. Jonas N. Jonas - Civil Engineer 7. ________

. Peerless J. Snow - Limestone Town Manager 8. ________

. J. E. Giles, Jr. - Project Manager* 9. ________

. ________ 10. ________

*Separate Inspection Dec. 30, 1980 Aug. 12, 1981

PROJECT FEATURE	INSPECTED BY	REMARKS
All of the project features were inspected by each of the party members.		

INSPECTION CHECKLIST

PROJECT Limestone Community Dam

DATE Nov. 8, 1979

PROJECT FEATURE Earthfill dam w/concrete spillway

NAME Lewis B. Seward

DISCIPLINE Hydro

NAME Jan N.Jonas

AREA EVALUATED	CONDITIONS
ɩM EMBANKMENT	
·est Elevation	534
ɩrrent Pool Elevation	527
.ximum Impoundment to Date	Not available
.rface Cracks	none visible
vement Condition	grassed and riprap at water line
vement or Settlement of Crest	not noticeable
teral Movement	not noticed
rtical Alignment	not noticed
rizontal Alignment	good
ndition at Abutment and at Concrete ructures	very good - earthfill and riprap
dications of Movement of Structural ems on Slopes	none visible
espassing on Slopes	none
ȝetation on Slopes	thick grass, not mowed
ɔughing or Erosion of Slopes or ɩtments	none -
ɔk Slope Protection - Riprap ilures	riprap at concrete intake walls- good condition
ɩsual Movement or Cracking at or ɩr Toes	none noticed
ɩsual Embankment or Downstream ɜpage	none
ɔing or Boils	none
ɩndation Drainage Features	2-in pipe relieving ports at toe of concrete spillway
ɜ Drains	see above
ɜtrumentation System	none

INSPECTION CHECKLIST

PROJECT Limestone Community Dam DATE Nov. 8, 1979

PROJECT FEATURE Earthfill dam in concrete spillway NAME Lewis B. Seward

DISCIPLINE NAME Jan N. Jonas

AREA EVALUATED	CONDITIONS
UTLET WORKS - INTAKE CHANNEL AND NTAKE STRUCTURE	
• Approach Channel	Not applicable
Slope Conditions	
Bottom Conditions	
Rock Slides or Falls	
Log Boom	
Debris	
Condition of Concrete Lining	
Drains or Weep Holes	
• Intake Structure	
Condition of Concrete	New precast pipe
Stop Logs and Slots	Not aplicable

INSPECTION CHECKLIST

PROJECT Limestone Community Dam DATE Nov. 8, 1979

PROJECT FEATURE Earthfill dam w/concrete NAME Lewis B. Seward

DISCIPLINE Hydro NAME Jan N. Jonas

AREA EVALUATED	CONDITIONS
TLET WORKS - CONTROL TOWER	
Concrete and Structural	
General Condition	very good
Condition of Joints	tight
Spalling	none
Visible Reinforcing	none
Rusting or Staining of Concrete	none
Any Seepage or Efflorescene	none
Joint Alignment	good
Unusual Seepage or Leaks in Gate Chamber	gate shaft was not accessible
Cracks	none
Rusting or Corrosion of Steel	none
Mechanical and Electrical	
Air Vents	none
Float Wells	none
Crane Hoist	none
Elevator	none
Hydraulic System	none
Service Gates	none
Emergency Gates	manually operated gate valve
Lightning Protection System	none
Emergency Power System	none
Wiring and Lighting System in Gate Chamber	none

INSPECTION CHECKLIST

PROJECT Limestone Community Dam DATE Nov. 8, 1979

PROJECT FEATURE Earthfill dam in concrete spillway NAME Lewis B. Seward

DISCIPLINE NAME Jan N. Jonas

AREA EVALUATED	CONDITIONS
)UTLET WORKS - TRANSITION AND CON-)UIT	
;eneral Condition of Concrete	Concrete pipe buried under dam embankment - not accessible for inspection.
;ust or Staining on Concrete	
;palling	
;rosion or Cavitation	
racking	
.lignment of Monoliths	
.lignment of Joints	
umbering of Monoliths	

INSPECTION CHECKLIST

PROJECT Limestone Community Dam | DATE Nov. 8, 1979

PROJECT FEATURE Earthfill dam w/concrete spillway | NAME Lewis B. Seward

DISCIPLINE Hydro | NAME Jan N. Jonas

AREA EVALUATED	CONDITIONS
UTLET WORKS - OUTLET STRUCTURE ND OUTLET CHANNEL	
eneral Condition of Concrete	precast concrete pipe w/riprap
ust or Staining	none
palling	none
rosion or Cavitation	none
isible Reinforcing	none
ny Seepage or Efflorescence	none
ondition at Joints	good, tight joints
rain Holes	none visible
hannel	
Loose Rock or Trees Overhanging Channel	none
Condition of Discharge Channel	grassed slopes w/riprap

INSPECTION CHECKLIST

PROJECT Limestone Community Dam — DATE Nov. 8, 1979

PROJECT FEATURE Earthfill Dam w/concrete spillway — NAME Lewis B. Seward

DISCIPLINE — NAME Jan N. Jonas

AREA EVALUATED	CONDITIONS
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	spillway located in the middle of dam
General Condition	
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Approach Channel	
b. Weir and Training Walls	
General Condition of Concrete	new concrete - very good
Rust or Staining	none
Spalling	none
Any Visible Reinforcing	none
Any Seepage or Efflorescence	none
Drain Holes	none
c. Discharge Channel	natural river channel
General Condition	good
Loose Rock Overhanging Channel	none
Trees Overhanging Channel	none
Floor of Channel	rocky
Other Obstructions	none

INSPECTION CHECKLIST

PROJECT Limestone Community Dam

DATE Nov. 8, 1979

PROJECT FEATURE Earthfill dam w/concrete spillway

NAME Lewis B. Seward

DISCIPLINE Hydro

NAME Jan N. Jonas

AREA EVALUATED	CONDITIONS
OUTLET WORKS - SERVICE BRIDGE	Not applicable
a. Super Structure	
Bearings	
Anchor Bolts	
Bridge Seat	
Longitudinal Members	
Under Side of Deck	
Secondary Bracing	
Deck	
Drainage System	
Railings	
Expansion Joints	
Paint	
b. Abutment & Piers	
General Condition of Concrete	
Alignment of Abutment	
Approach to Bridge	
Condition of Seat & Backwall	

APPENDIX B

ENGINEERING DATA

Note: 1. All design records are in storage at the:

National Archives and Records Service
GSA Federal Archives and Records Center
380 Trapelo Road, Waltham, Massachusetts 02154
617-223-2657

2. No past inspection reports were available for review or are known to exist.

LIST OF ENCLOSED DRAWINGS

A. "Rehabilitation of Community Dam," Project No. 20131.

		Drawing Number
1.	Existing Structure and Site Preparation	C-100 Sheet 1 of 8
2.	Concrete Sections	C-102 Sheet 3 of 8
3.	Sections	C-300 Sheet 4 of 8

B. "Reconstruction of Community Dam," Project No. 7409963 E.

		Sheet Number
4.	Existing Site and Exploration Plan	1
5.	Dam and Swimming Area Plan	7
6.	Dam Profile and Gabion Plan View	8
7.	Dam Cross Section	10
8.	Subsurface Geologic Profile	16

References

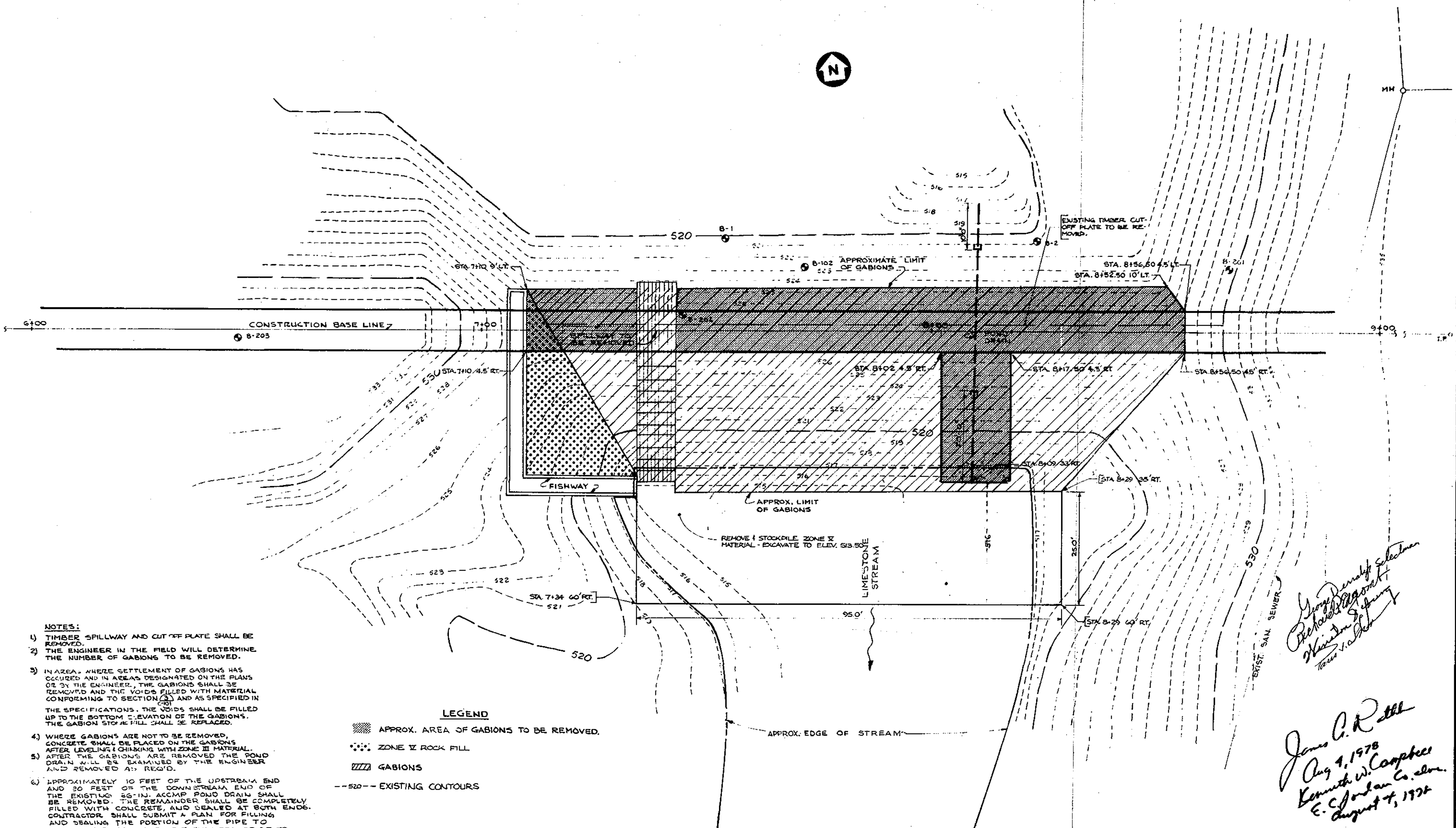
Material from the following references was extracted and incorporated herein:

a. "Limestone Stream Watershed Work Plan" Central Aroostook Soil Conservation District December, 1964.

b. Limestone Community Dam Construction Drawings: "Rehabilitation of Community Dam" (8 sheets), 1978 and also "Reconstruction of Community Dam" (21 sheets), 1976.

c. "Durepo Brook - Invitation to Bid" March 1971 SCS construction specification (Typ.)

d. SCS Technical Information Storage and Retrieval System Printout.



NOTES:

1) TIMBER SPILLWAY AND CUT OFF PLATE SHALL BE REMOVED.
2) THE ENGINEER IN THE FIELD WILL DETERMINE THE NUMBER OF GABIONS TO BE REMOVED.
3) IN AREAS WHERE SETTLEMENT OF GABIONS HAS OCCURED AND IN AREAS DESIGNATED ON THE PLANS OR BY THE ENGINEER, THE GABIONS SHALL BE REMOVED AND THE VOIDS FILLED WITH MATERIAL CONFORMING TO SECTION 3 C-101 AND AS SPECIFIED IN THE SPECIFICATIONS. THE VOIDS SHALL BE FILLED UP TO THE BOTTOM ELEVATION OF THE GABIONS. THE GABION STONE FILL SHALL BE REPLACED.
4.) WHERE GABIONS ARE NOT TO BE REMOVED, CONCRETE SHALL BE PLACED ON THE GABIONS AFTER LEVELING & CHINKING WITH ZONE III MATERIAL.
5.) AFTER THE GABIONS ARE REMOVED THE POND DRAIN WILL BE EXAMINED BY THE ENGINEER AND REMOVED AS REQ'D.
6.) APPROXIMATELY 10 FEET OF THE UPSTREAM END AND 20 FEET OF THE DOWNSTREAM END OF THE EXISTING 36-IN. ACCMP POND DRAIN SHALL BE REMOVED. THE REMAINDER SHALL BE COMPLETELY FILLED WITH CONCRETE, AND SEALED AT BOTH ENDS. CONTRACTOR SHALL SUBMIT A PLAN FOR FILLING AND SEALING THE PORTION OF THE PIPE TO REMAIN FOR REVIEW BY THE ENGINEER PRIOR TO INITIATING THE WORK.

LEGEND

- APPROX. AREA OF GABIONS TO BE REMOVED.
- ZONE V ROCK FILL
- GABIONS
- --520-- EXISTING CONTOURS

HERITAGE CONSERVATION & RECREATION SERVICE
PROJECT Nº 23-00303

REV	DATE	STATUS	MF	BY	CHK'D	APP'D
0		FOR CONSTRUCTION				
A	7/14/78	ISSUED FOR BIDS				

NO. | REFERENCE

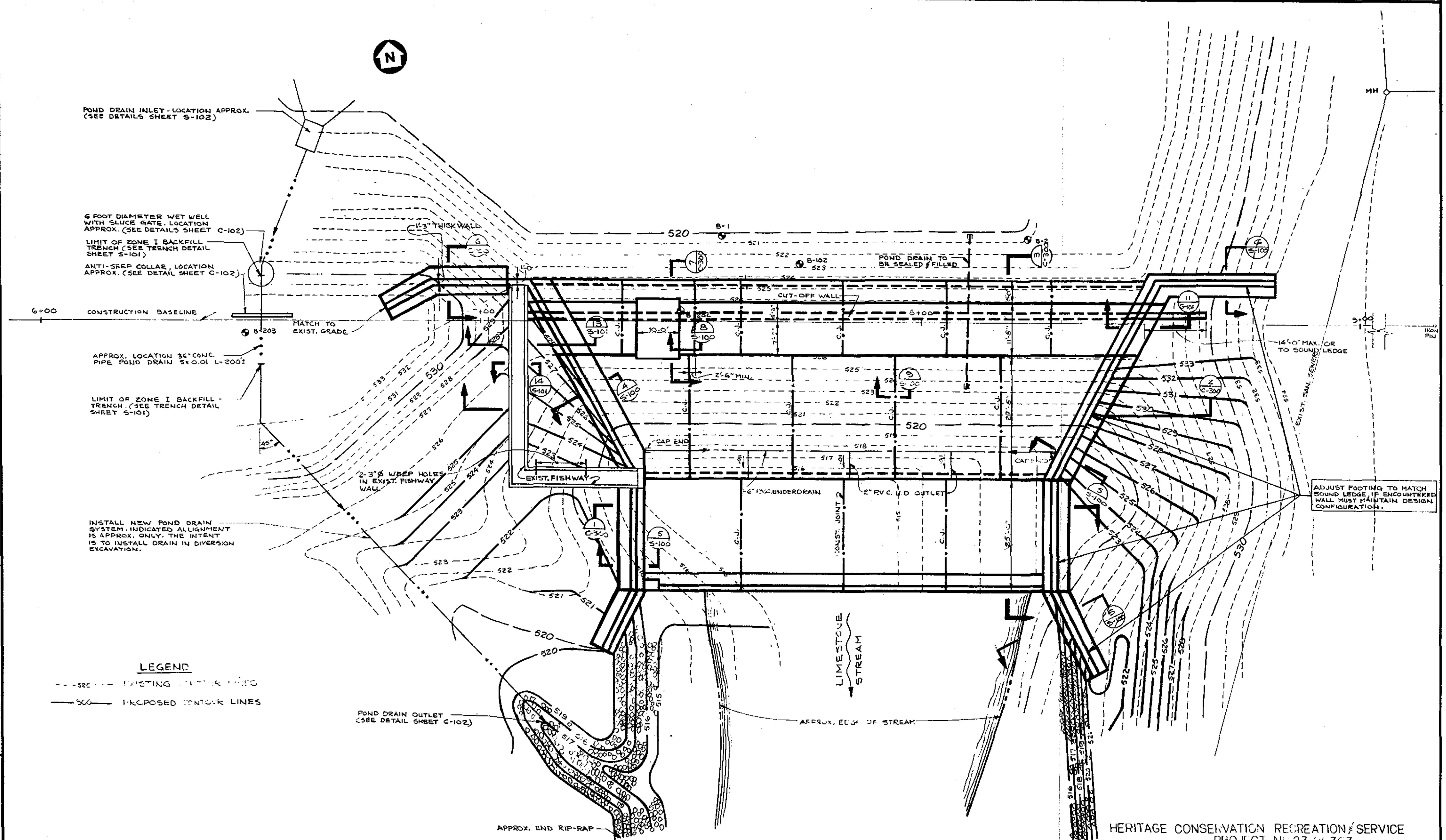
EDWARD C. JORDAN CO., INC.
ENGINEERING · PLANNING · ARCHITECTURE
PORTLAND · BANGOR · PRESQUE ISLE, MAINE

CLIENT: TOWN OF LIMESTONE
LIMESTONE, MAINE

DESIGN: BAW 7-14-78
DRAWN: R.B.G.
PROCESS: 07-14-78
SCALE: 1" = 10'

TITLE: REHABILITATION OF COMMUNITY DAM
EXISTING STRUCTURE & SITE PREPARATION

PROJECT NO.: 20131
DWG NO.: C-100 SHT. 1 OF 8
REV. 0



HERITAGE CONSERVATION RECREATION & SERVICE
PROJECT Nº 23-00303

REV.	DATE	STATUS
O		FOR CONSTRUCTION
B	7/21/78	GEN'L. REVISION
A	7/14/78	ISSUED FOR BID

NO. | REFERENCE | REV. | DATE | STATUS | MF | BY | CHK'D | APP'D

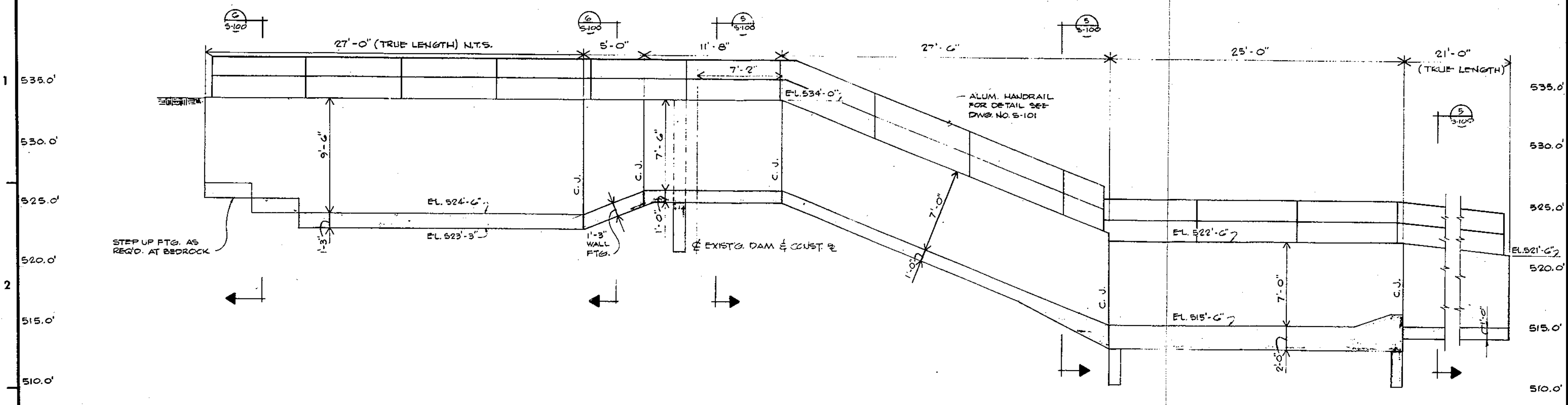
EDWARD C. JORDAN CO., INC.
ENGINEERING · PLANNING · ARCHITECTURE
PORTLAND · BANGOR · PRESQUE ISLE, MAINE

CLIENT: TOWN OF LIMESTONE
LIMESTONE, MAINE

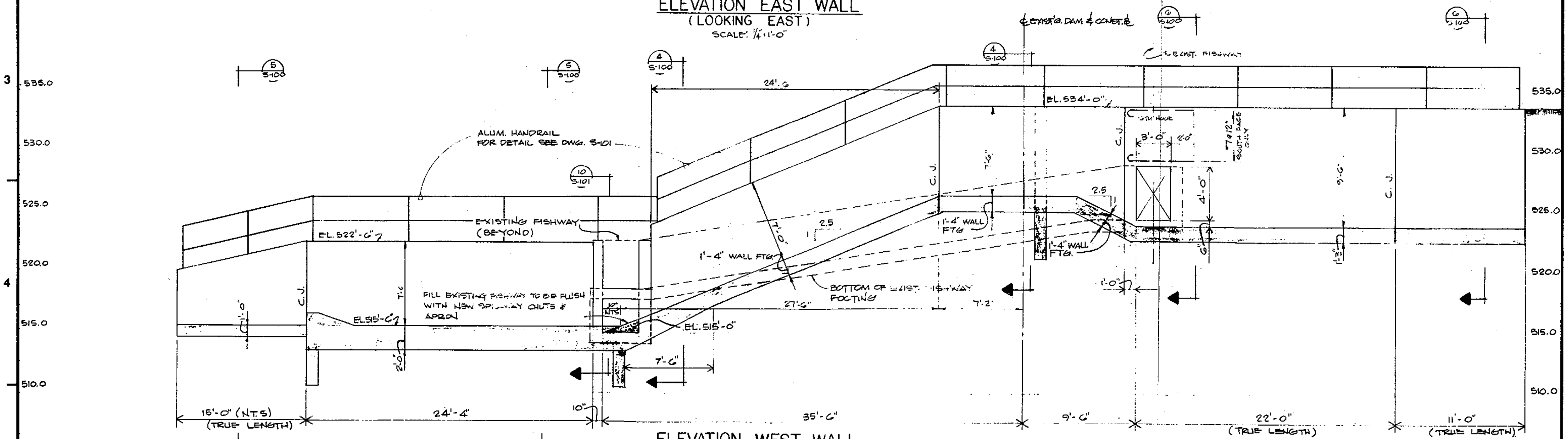
DESIGN	BAW	7-19-78
DRAWN	G.D.C.	7/19/78
CHK'D		
DEPT. HD.		
PROCESS		7-19-78
PROJ MGR		
CLIENT		
SCALE	1" = 10'	

TITLE: REHABILITATION OF COMMUNITY DAM
GENERAL PLAN

PROJECT NO. 20131
DWG NO. C-101 SHEET 2 OF 8
REV. O



ELEVATION EAST WALL
(LOOKING EAST)
SCALE: 1/4"=1'-0"



ELEVATION WEST WALL
(LOOKING WEST)
SCALE: 1/4"=1'-0"

HERITAGE CONSERVATION & RECREATION SERVICE
PROJECT № 23-00303

REV	DATE	STATUS	MF	BY	CHK'D	APP'D
0		FOR CONSTRUCTION				
B	7/21/78	GEN'L. REVISION				
A	7/14/78	ISSUED FOR BIDS				

NO.	REFERENCE

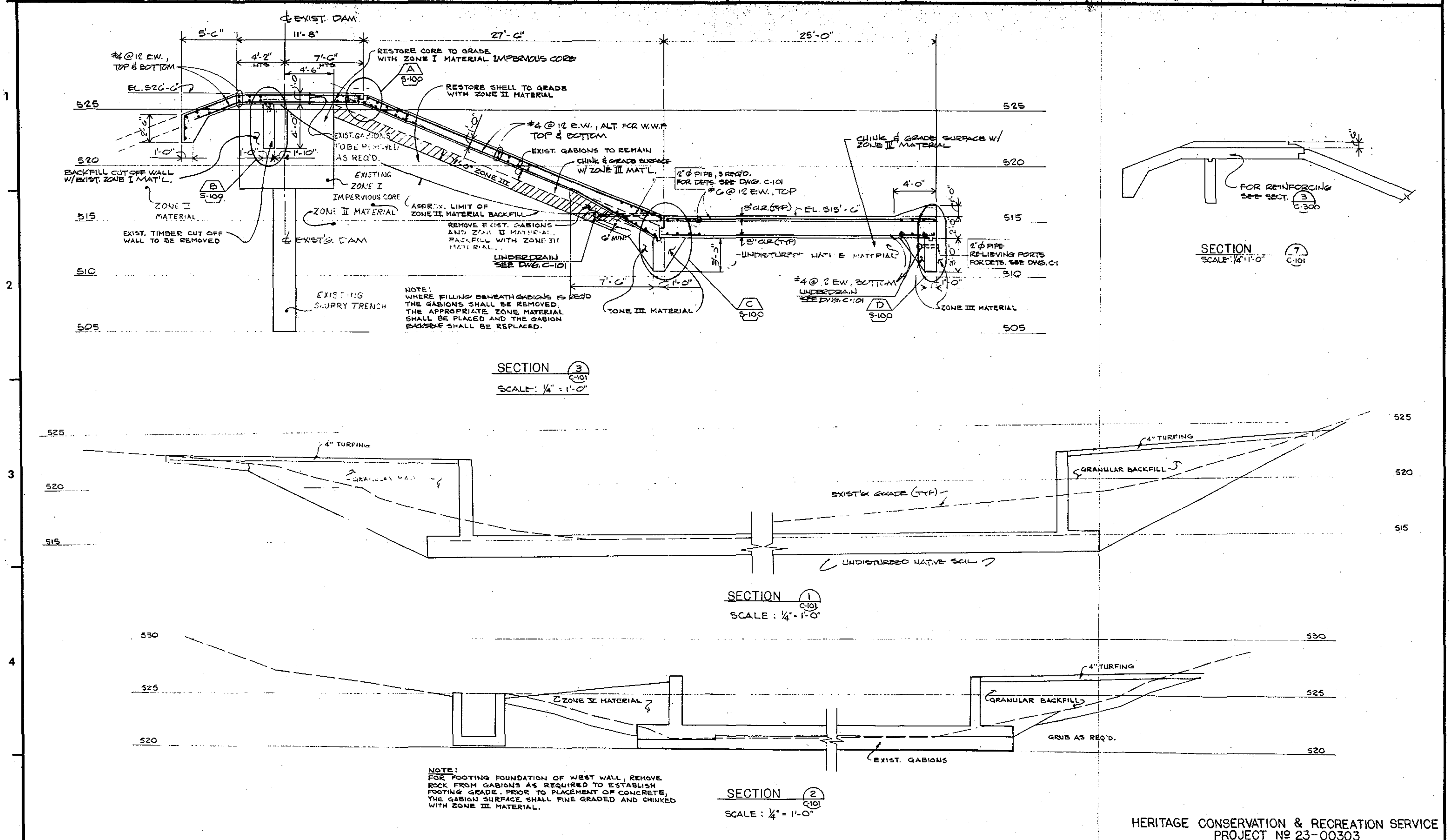
EDWARD C. JORDAN CO., INC.
ENGINEERING · PLANNING · ARCHITECTURE
PORTLAND · BANGOR · PRESQUE ISLE, MAINE

CLIENT: TOWN OF LIMESTONE
LIMESTONE, MAINE

DESIGN: 7/18/78
DRAWN: E. A. Pura 07/18/78
PROCESS: 07-14-78
SCALE: AS NOTED

TITLE: REHABILITATION OF COMMUNITY DAM
CONCRETE SECTIONS

PROJECT NO. 20131
DWG NO. C 102 SHT 3 OF 8
REV. 0



HERITAGE CONSERVATION & RECREATION SERVICE
PROJECT № 23-00303

NO.	REFERENCE	REV.	DATE	STATUS	MF	BY	CHK'D	APP'D
		0		FOR CONSTRUCTION				
		B	7/21/78	GEN'L. REVISION				
		A	7/14/78	ISSUED FOR BIDS				

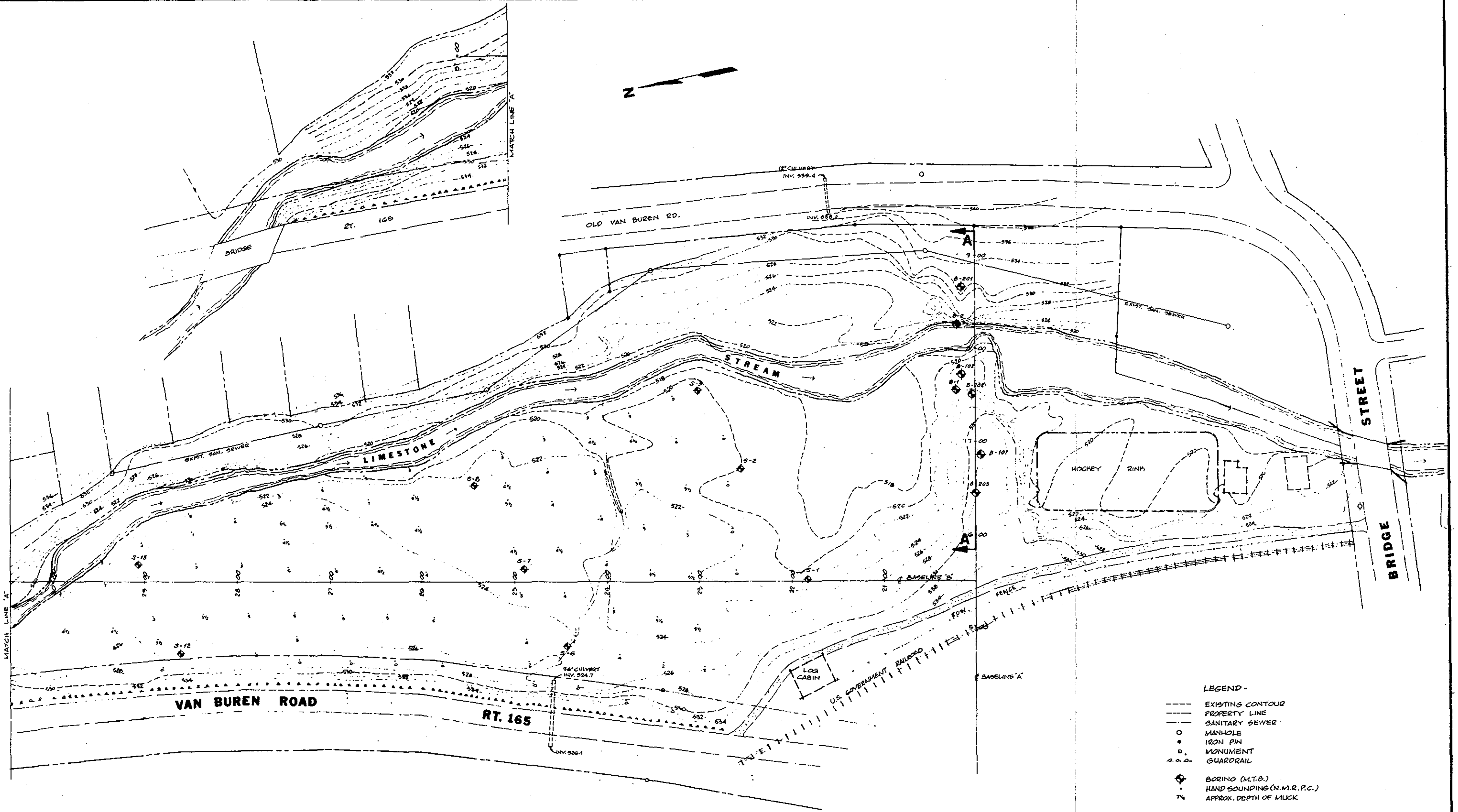
EDWARD C. JORDAN CO., INC.
ENGINEERING · PLANNING · ARCHITECTURE
PORTLAND · BANGOR · PRESQUE ISLE, MAINE

CLIENT: TOWN OF LIMESTONE
LIMESTONE, MAINE

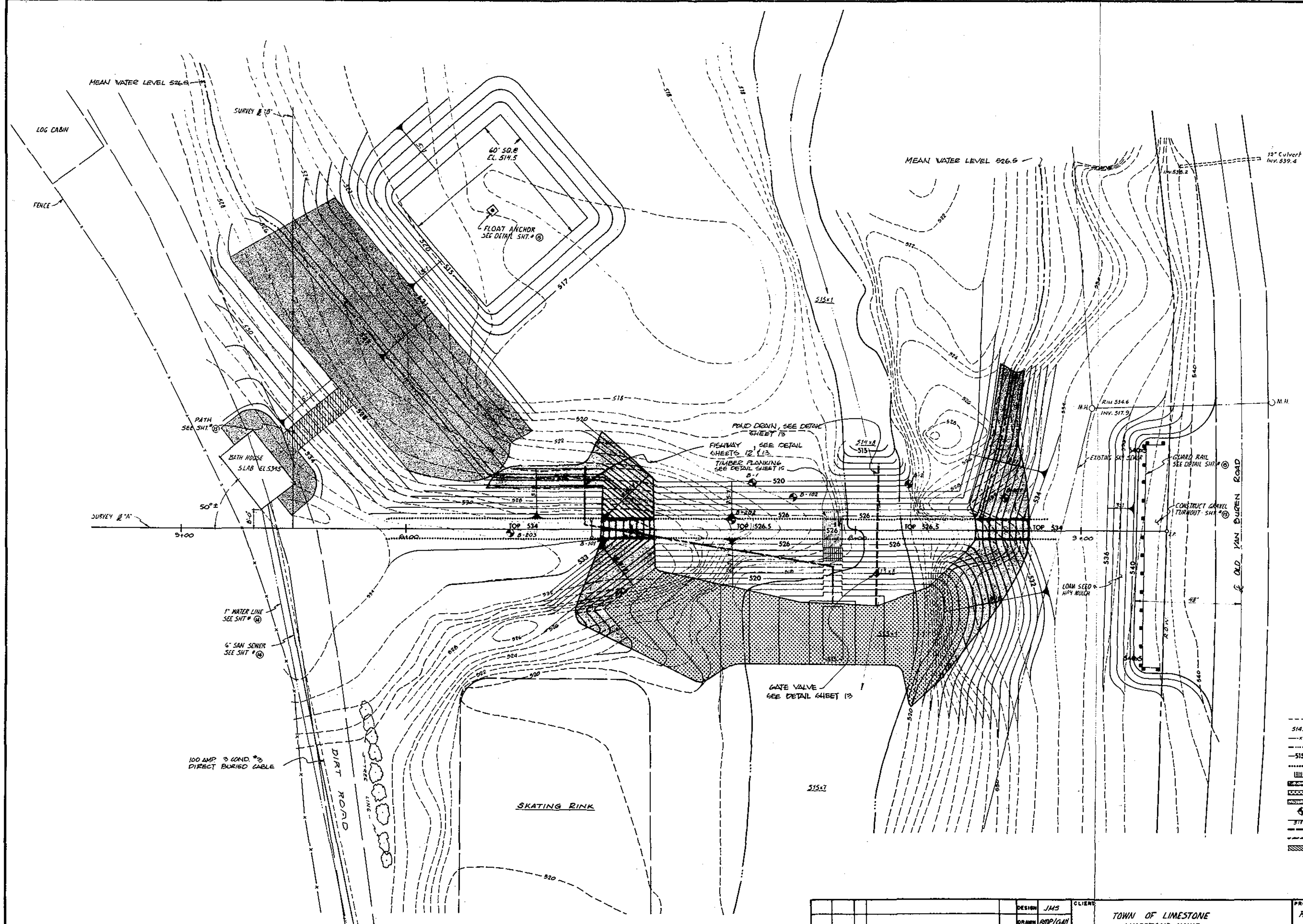
DESIGN: 7/14/78
DRAWN: 7-14-78
PROCESS: 07-14-78
SCALE: 1/4" = 1'-0"

TITLE: REHABILITATION OF COMMUNITY DAM
SECTIONS

PROJECT NO.: 20131
DWG. NO.: C-300 SHEET 4 OF 8
REV.: 0



REV.	DATE	HP	STATUS	APPD.			CLIENT:	PROJECT:	SHEET NO.
					DESIGN	S.C.	TOWN OF LIMESTONE LIMESTONE, MAINE	RECONSTRUCTION OF COMMUNITY DAM	①
					DRAWN	MP			DRAWING NO.
					CHECK				
					APPD.		Jordan Gorrill Associates Geotechnical Consultants	TITLE: EXISTING SITE & EXPLORATION PLAN	
					APPD.				
					APPD.	DB	PORTLAND, BANGOR AND PRESQUE ISLE, MAINE	SCALE: 1"=50' JOB NO. 7409963E	REV. NO.



NOTE -

1. ALL DISTURBED AREAS ABOVE EL. 526.5 SHALL BE LOAMED, SEEDED, AND MULCHED UNLESS OTHERWISE NOTED

LEGEND -

- EXISTING CONTOURS
- 514x8 EXISTING SPOT ELEVATIONS
- EXISTING FENCE
- APPROX. EXISTING STREAM
- —515— FINISH CONTOURS
- TOP OF DAM LIMITS
- WOOD CRIB OVERFLOW
- RIP-RAP - 12" DEEP
- STONE FILL - 18" DEEP
- SAND BEACH 12" DEEP
- BORING LOCATION
- 3:1 SLOPE INDICATOR
- POND DRAIN
- FISHWAY
- CRUSHER DUST

REV.	DATE	MF	STATUS	APPD.		
					DESIGN	JMS
					DRAWN	RMP/GAH
					CHECK	GW
	7/8/76		~~AS ADVERTISED~~		APPD.	
	8/20/76		AS SUBMITTED FOR REVIEW		APPD.	
					APPD.	GB

CLIENT: TOWN OF LIMESTONE
LIMESTONE, MAINE

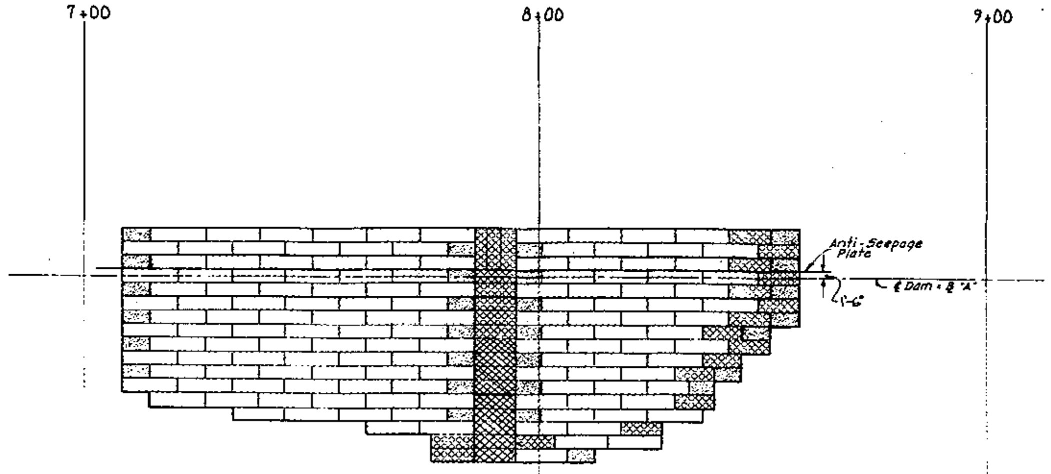
EDWARD C. JORDAN CO., INC.
ENGINEERING, PLANNING, ARCHITECTURE
PORTLAND, BANGOR, AND PRESQUE ISLE, MAINE

PROJECT: RECONSTRUCTION OF COMMUNITY DAM

TITLE: DAM & SWIMMING AREA PLAN

SCALE: 1"=20' | JOB NO. 7409963 E

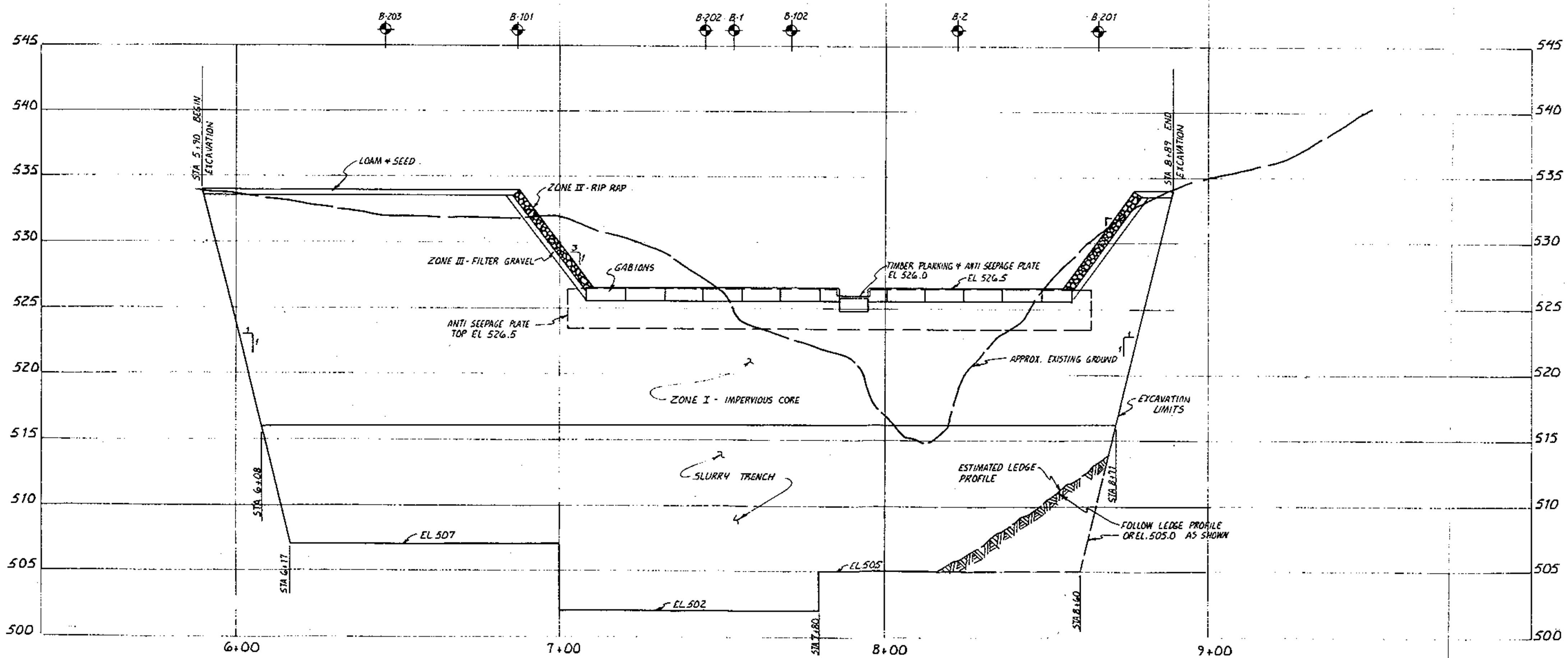
SHEET NO. 7 | DRAWING NO. | REV. NO.



GABION PLAN VIEW

LEGEND-

- 3'x6' Gabion 12" Deep
- 3'x9' Gabion 12" Deep
- 3'x12' Gabion 12" Deep
- 3'x9' Gabion 18" Deep



DAM PROFILE

◆ INDICATES BORINGS (NOTE: BORINGS MAY BE OFFSET FROM BASELINE SEE SHT #7 FOR LOCATION)

INCHES — CENTIMETERS — DO NOT SCALE DRAWING

REV.	DATE	MF	STATUS	APPD
	9/8/76		AS ADVERTISED	
	8/26/76		AS SUBMITTED FOR REVIEW	

DESIGN: SWC
DRAWN: GAH
CHECK: SWC
APPD: GO
APPD: QB

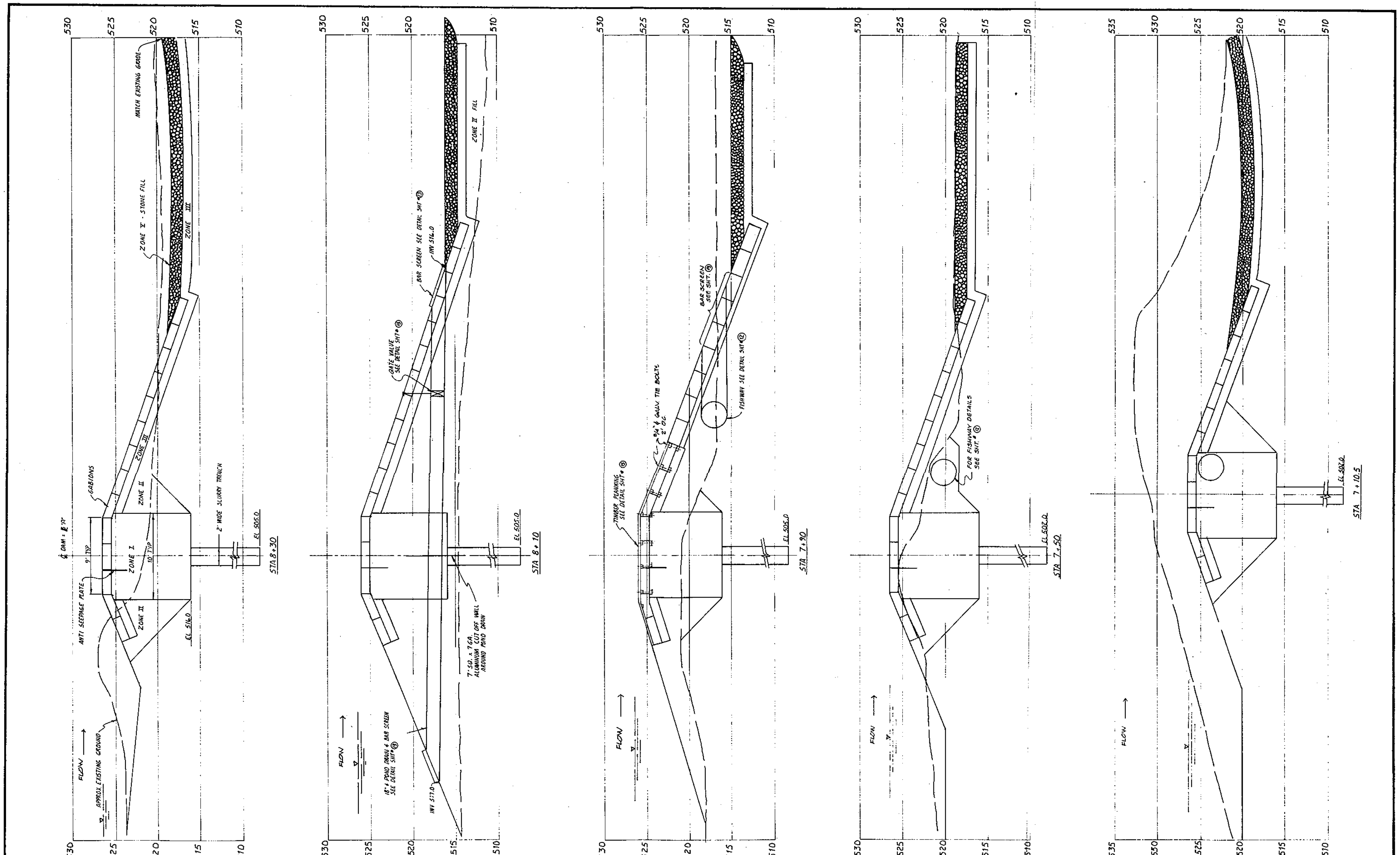
CLIENT: TOWN OF LIMESTONE, LIMESTONE, MAINE

EDWARD C. JORDAN CO., INC.
ENGINEERING, PLANNING, ARCHITECTURE
PORTLAND, BANGOR, AND PRESQUE ISLE, MAINE

PROJECT: RECONSTRUCTION OF COMMUNITY DAM

TITLE: DAM PROFILE & GABION PLAN VIEW

SCALE: 1"=20' | JOB NO. 7409963E | SHEET NO. 8 | DRAWING NO. | REV. NO.



INCHES
CENTIMETERS
DO NOT SCALE DRAWING

				DESIGN	SWC
				DRAWN	GAN
				CHECK	SWC
	9/8/76		AS ADVERTISED	APPD	QW
	8/20/76		AS SUBMITTED FOR REVIEW	APPD	
REV.	DATE	MF	STATUS	APPD.	APPD DB

CLIENT: TOWN OF LIMESTONE
LIMESTONE, MAINE

EDWARD C. JORDAN CO., INC.
ENGINEERING, PLANNING, ARCHITECTURE
PORTLAND, BANGOR, AND PRESQUE ISLE, MAINE

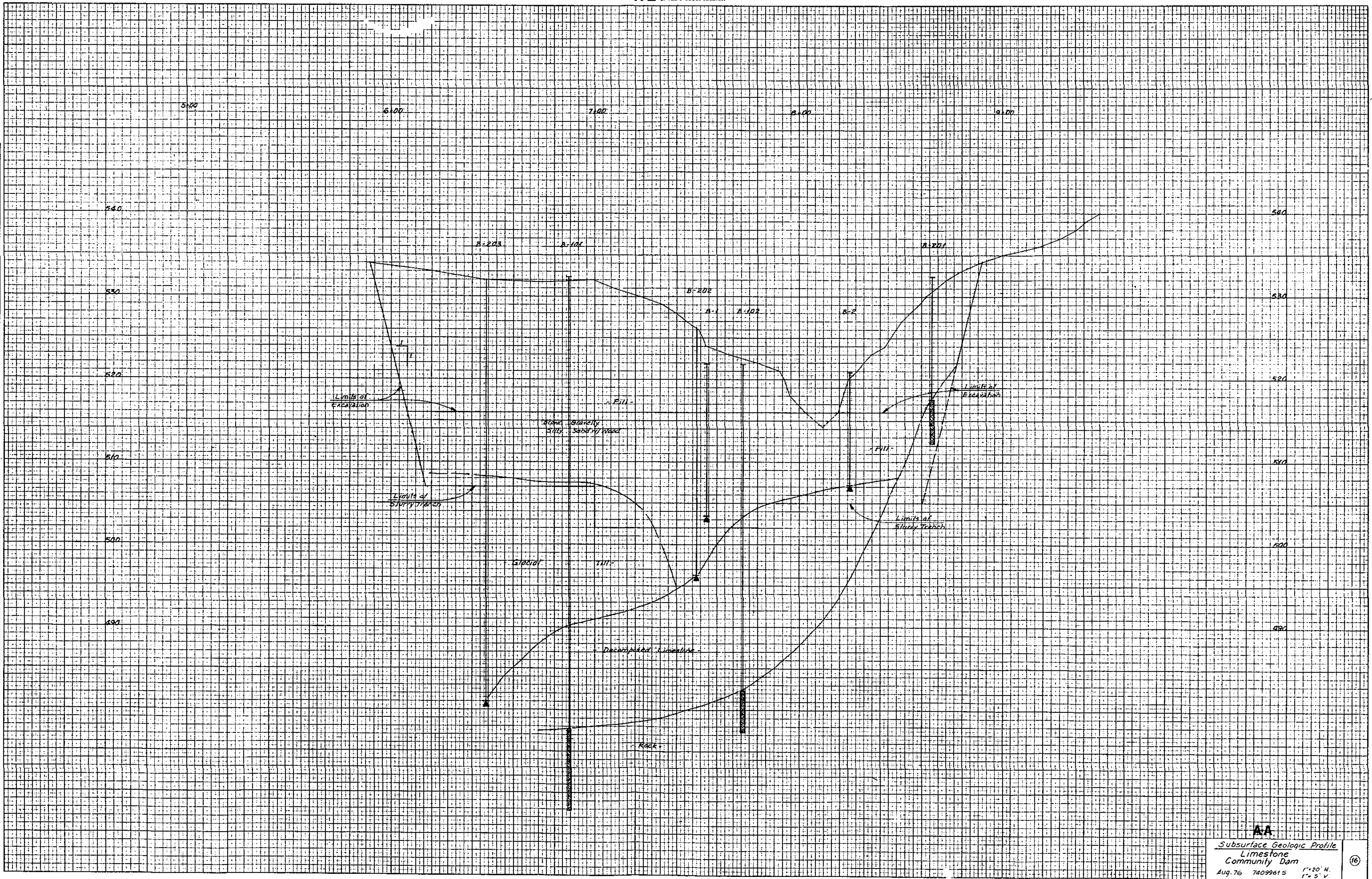
PROJECT: RECONSTRUCTION OF COMMUNITY DAM

SHEET NO. 10

DRAWING NO.

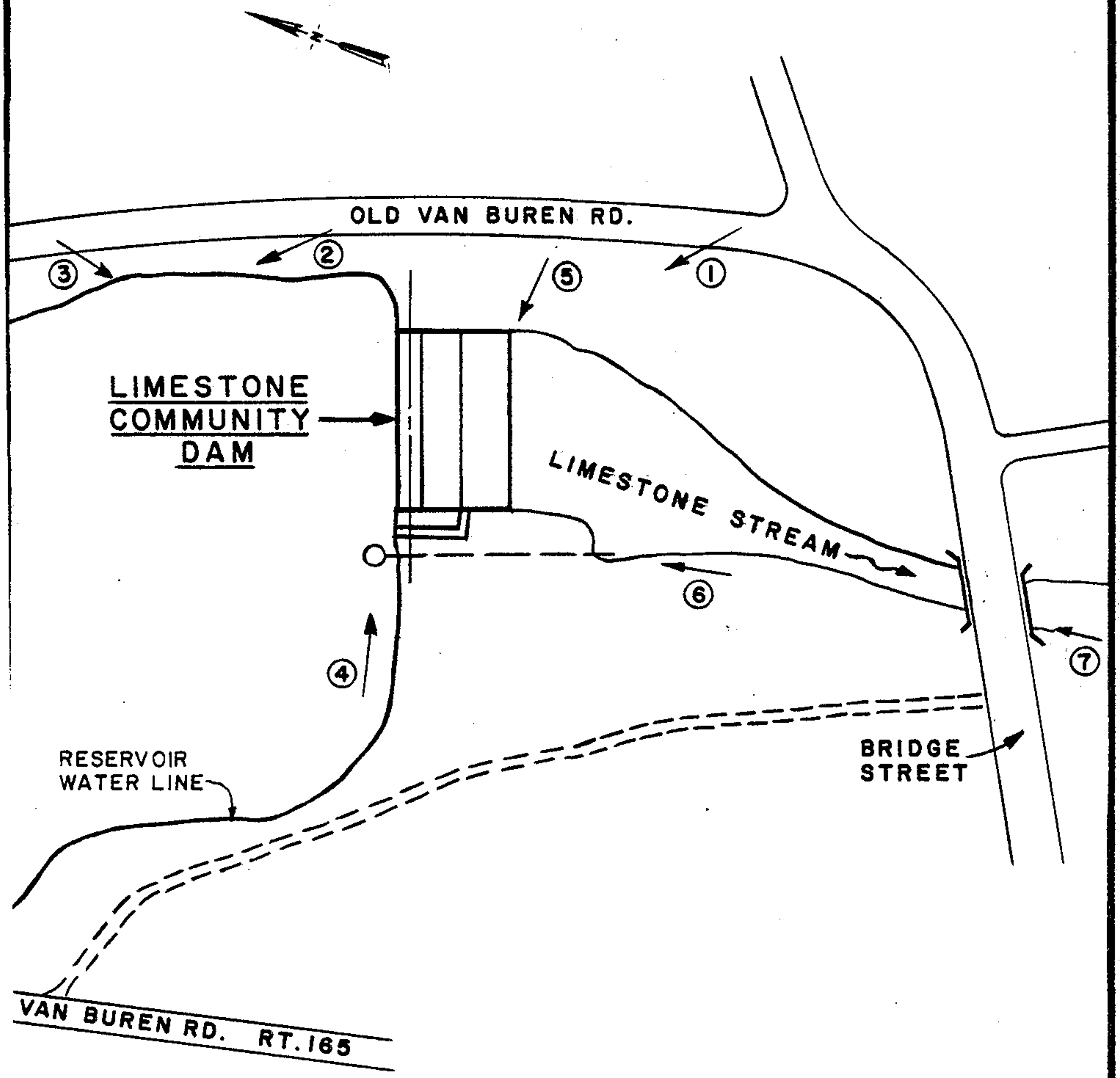
TITLE: DAM CROSS SECTION

SCALE: 1"=5' | JOB NO. 7409963E | REV. NO.


5+00
6+00
7+00
8+00
9+00
540
530
520
510
500
490
B-203
B-101
B-202
B-1
B-102
B-2
B-201
Limits of Excavation
- Fill -
Stone, Gravelly Silty Sand w/ Wood
Limits of Slurry Trench
- Glacial Till -
- Decomposed Limestone -
- Rock -
A-A
Subsurface Geologic Profile
Limestone Community Dam
Aug. 76 74099615
1" = 20' H.
1" = 5' V.
16

APPENDIX C

PHOTOGRAPHS



LEGEND

① PHOTO LOCATION

LIMESTONE COMMUNITY DAM-PHOTO LOCATION

U.S. ARMY CORPS OF ENGINEERS
PHASE I INSPECTION PROGRAM

MAIN

DATE November, 1980

CLIENT	JOB	PLATE
1345	72	2

PHOTO #1

VIEW FROM LEFT BANK ACROSS OLD HIGHWAY 165

PHOTO # 2

VIEW FROM LEFT BANK ACROSS OLD HIGHWAY 165

PHOTO # 3

UPSTREAM VIEW OF RE- SERVOIR WITH NEW HIGHWAY 165

PHOTO # 4

RIGHT ABUTMENT WITH ROCKFILL DAM AND VALVE SHAFT

PHOTO # 5

SPILLWAY WITH FISH LADDER AND VALVE SHAFT

PHOTO # 6

OUTLET PIPE (36") FISH LADDER WITH RE-TAINING WALL AND SPILLWAY

PHOTO #7

VIEW UPSTREAM FROM

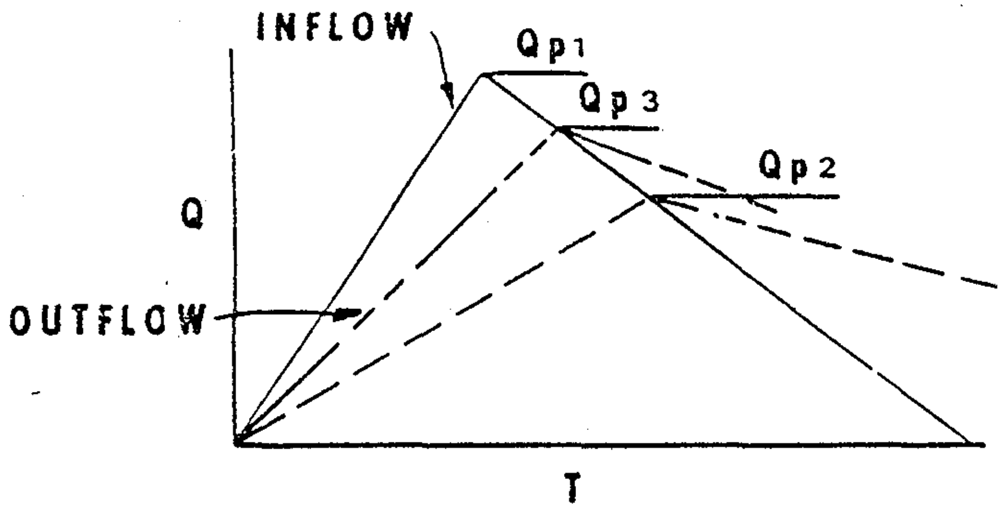
BELOW HIGHWAY 229

BRIDGE

APPENDIX D

HYDROLOGIC & HYDRAULIC COMPUTATIONS

ESTIMATING EFFECT OF SURCHARGE STORAGE ON MAXIMUM PROBABLE DISCHARGES



STEP 1: Determine Peak Inflow (Q_{p1}) from Guide Curves.

STEP 2: a. Determine Surcharge Height To Pass "Q_{p1}".

b. Determine Volume of Surcharge ($STOR_1$) In Inches of Runoff.

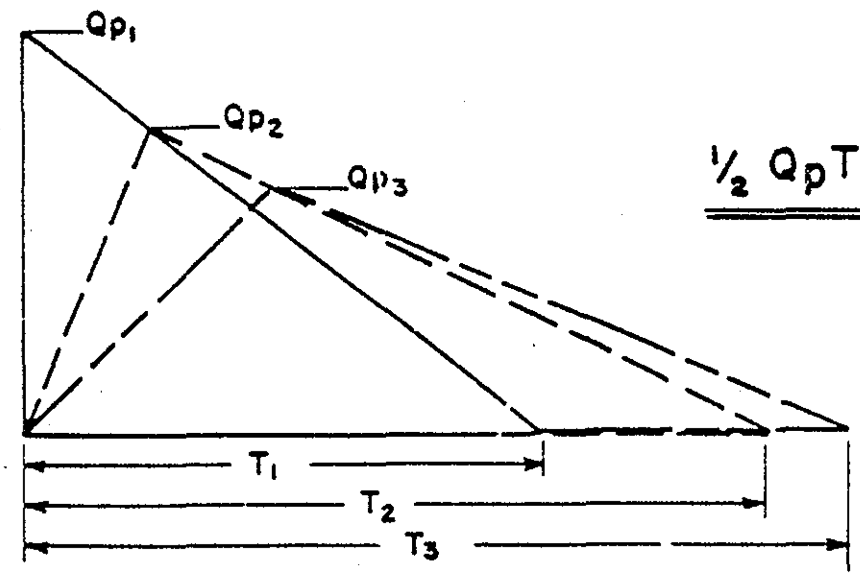
c. Maximum Probable Flood Runoff In New England equals Approx. 19", Therefore:

$$Q_{p2} = Q_{p1} \times \left(1 - \frac{STOR_1}{19}\right)$$

STEP 3: a. Determine Surcharge Height and "$STOR_2$" To Pass "Q_{p2}"

b. Average "$STOR_1$" and "$STOR_2$" and Determine Average Surcharge and Resulting Peak Outflow "Q_{p3}".

"RULE OF THUMB" GUIDANCE FOR ESTIMATING DOWNSTREAM DAM FAILURE HYDROGRAPHS



$$\frac{1}{2} Q_p T = 12\,S$$

STEP 1: DETERMINE OR ESTIMATE RESERVOIR STORAGE (S) IN AC-FT AT TIME OF FAILURE.

STEP 2: DETERMINE PEAK FAILURE OUTFLOW (Q_{p1}).

$$Q_{p1} = \frac{8}{27} W_b \sqrt{g}\, Y_o^{3/2}$$

W_b = BREACH WIDTH - SUGGEST VALUE NOT GREATER THAN 40% OF DAM LENGTH ACROSS RIVER AT MID HEIGHT.

Y_o = TOTAL HEIGHT FROM RIVER BED TO POOL LEVEL AT FAILURE.

STEP 3: USING USGS TOPO OR OTHER DATA, DEVELOP REPRESENTATIVE STAGE-DISCHARGE RATING FOR SELECTED DOWNSTREAM RIVER REACH.

STEP 4: ESTIMATE REACH OUTFLOW (Q_{p2}) USING FOLLOWING ITERATION.

A. APPLY Q_{p1} TO STAGE RATING, DETERMINE STAGE AND ACCOPMANYING VOLUME (V_1) IN REACH IN AC-FT. (NOTE: IF V_1 EXCEEDS 1/2 OF S, SELECT SHORTER REACH.)

B. DETERMINE TRIAL Q_{p2}.

$$Q_{p2}(\text{TRIAL}) = Q_{p1}\left(1 - \frac{V_1}{S}\right)$$

C. COMPUTE V_2 USING Q_{p2} (TRIAL).

D. AVERAGE V_1 AND V_2 AND COMPUTE Q_{p2}.

$$Q_{p2} = Q_{p1}\left(1 - \frac{V_{avg}}{S}\right)$$

STEP 5: FOR SUCCEEDING REACHES REPEAT STEPS 3 AND 4.

APRIL 1978

SURCHARGE STORAGE ROUTING SUPPLEMENT

STEP 3: a. Determine Surcharge Height and "$STOR_2$" To Pass "Qp_2"

b. Avg "$STOR_1$" and "$STOR_2$" and Compute "Qp_3".

c. If Surcharge Height for Qp_3 and "$STOR_{AVG}$" agree O.K. If Not:

STEP 4: a. Determine Surcharge Height and "$STOR_3$" To Pass "Qp_3"

b. Avg. "Old $STOR_{AVG}$" and "$STOR_3$" and Compute "Qp_4"

c. Surcharge Height for Qp_4 and "New $STOR_{Avg}$" should Agree closely

MAIN

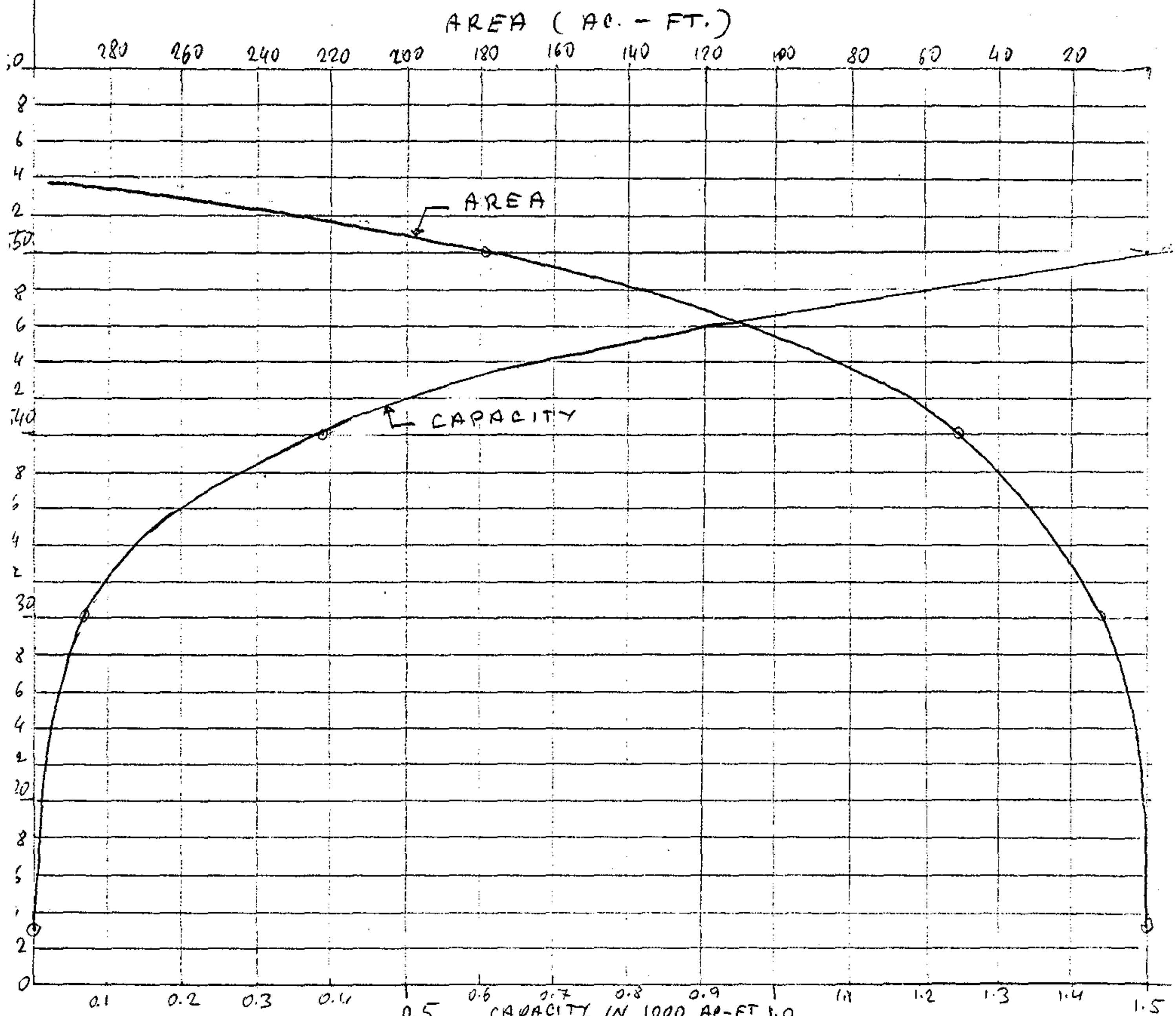
Client CORPS OF ENGINEERS Job No. 1345-072 -017 Sheet 1 of 24

Subject FLOOD ROUTING THROUGH RESERVOIR By T. OTOUA Date 4-14-80

LIMESTONE COMMUNITY DAM Ckd. ______ Rev. ______

CAPACITY CURVE CALCULATIONS:

ELV.	AREA (mi.²)	AREA (ACRE)	INCR. VOL. (AC-FT)	TOTAL VOL. (AC-FT)
513	0	0	0	0
530	0.02	12.8	72.5	72.5
540	0.08	51.2	320.0	392.5
550	0.28	179.2	1152.0	1544.5



MAIN

ient CORPS OF ENGINEERS Job No. 1345-072 -017 Sheet 2 of 24

ıbject LIMESTONE RESERVOIR By T. OTOVA Date 2-3-81

CAPACITY CURVE FITTING Ckd. Rev.

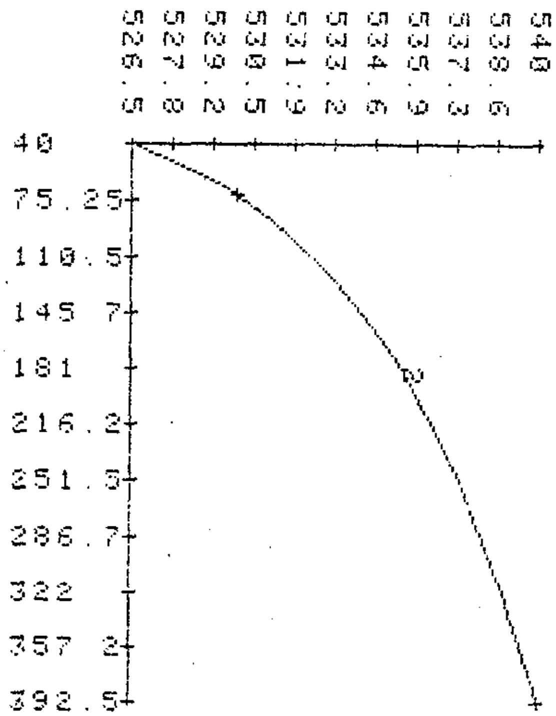
I	X(I)	Y(I)
1	40.0000	526.5000
2	72.5000	530.0000
3	392.5000	540.0000

AOV: LOG REG:CODE 2

SOURCE/DF		SS	MS	F
TOTAL	2	98.2		
REG	1	98.2	98.2	999.9
RESID	1	0.0	0.0	

R SQUARE = 1.000

YHAT= 504.678+ 5.914LOG X

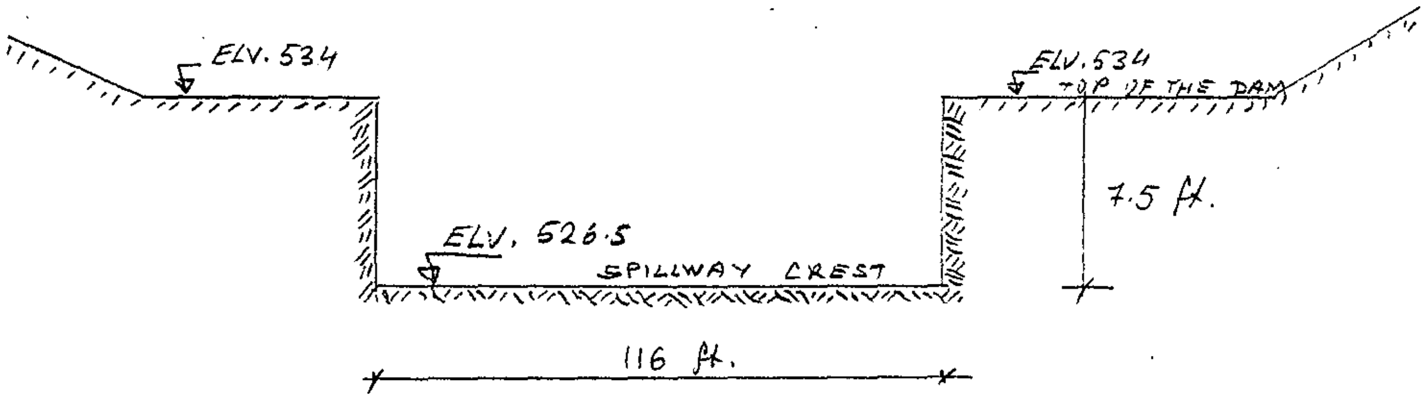


MAIN

Client CORPS OF ENGINEERS — Job No. 1345-072 -017 — Sheet 3 of 24

Subject LIMESTONE DAM — By T. OTOVA — Date 2-3-81

SPILLWAY RATING CURVE — Ckd. — Rev.



Broad Crested Weir Formula,

$$Q = C \times L \times H^{3/2}$$

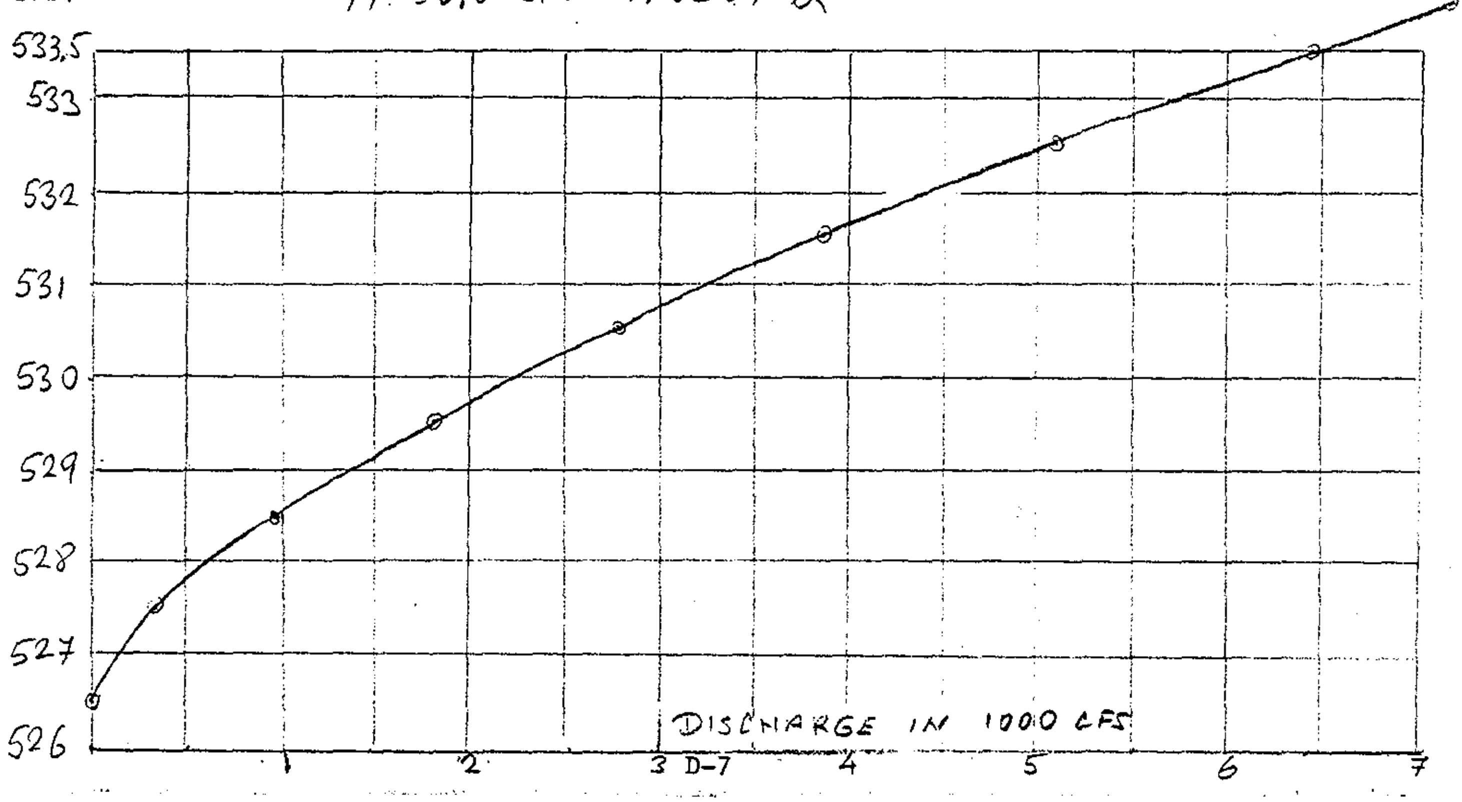
$$C \cong 3.0$$

$$L = 116$$

$$Q = 348 \times H^{3/2} \quad \text{or} \quad H = \frac{1}{(348)^{2/3}} \times Q^{2/3}$$

$$H = 0.021221655 \times Q^{0.66667}$$

ELV.



Drainage Area = 27.9 sq. mi.

For 19" runoff for rolling terraine $q_{PMF} = 1350$ cfs/sqm

$Q_{PMF} = 1350 \times 27.9 = 37665$ cfs.

For this part of MAINE the Depth-Area-Duration curves yield a 13" of runoff. The Corps of Engineers New England Division also agrees that 13" of runoff should be used in the calculations.

In this case

$$\text{New } Q_{PMF} = 37665 \times \frac{13}{19} = 25770 \text{ cfs.}$$

The test flood is selected to be 1/2 PMF for trial calculation. The routing calculations are presented in the following pages.

Test Flood = $25770 \times \frac{1}{2} = 12885$ cfs.

The flood routing calculations are presented in pages 5 and 6. As it can be seen from the results the dam is overtopping. Half of the test flood (1/4 PMF) is selected and the calculations are repeated (pages 7 and 8). The flood discharge (6409 cfs) is found to be almost equal to the spillway capacity (7147 cfs).

In order to estimate the amount of the overtopping the rating formula is altered to take care the discharge over the dam and though the natural sides.

The derivation of the rating formula is presented in pages 9 and 10. The rating table is tabulated in page 11. The rating curve is illustrated in page 12.

The routing calculations are shown in pages 13 and 14.

In view of the results presented in page 14 it is estimated that about 2.2 ft. overtopping will occure during the test flood (1/2 PMF).

MAIN

CORPS OF ENGINEERS — Job No. 1345-072 -017 — Sheet 5 of 24
LIMESTONE RESERVOIR — By T. OTOVA — Date 2-3-81
FLOOD ROUTING CALCULATIONS — Ckd. ______ Rev. ______

ESTIMATING

EFFECT OF SURCHARGE STORAGE ON MAXIMUM PROBABLE DISCHARGES

These calculations are performed according to the Corps of Engineers Guidelines

LIMESTONE DAM

D A T A :

DRAINAGE AREA,
A= 27.9 (sq.mi.)

PEAK INFLOW,
Qp1= 12885 (cfs)

PRINCIPAL SPILLWAY CREST ELEV.,
ELV1= 526.5 (ft.)

EMERGENCY SPILLWAY CREST ELEV.,
ELV2= 526.5 (ft.)

Emergency Spillway Rating Curve is defined as ,

H = a * Q ^ b

a = .0212211655
b = .66667

The Capacity - Elv. curve is defined as,

Elv = m + n * Log(Volume)

m= 504.678
n= 5.914

TOTAL PMF RUNOFF,
R= 13 (in.)

CALCULATIONS:

S T E P 1

Reduction of the Qp1 due to starting elevation at Principal Spillway crest elev.

Volume at 526.5 (ft.)

Volume1 =Exp((ELV1-m)/n)
Volume1 = 40.04 (ac-ft)

Volume at 526.5 (ft.)

Volume2 =Exp((ELV2-m)/n)
Volume2 = 40.04 (ac-ft)

Diff. of Volumes,

Diff.Volume = 0 (ac-ft)
or,
Diff.Volume, D= 0 (in.)

NEW Qp1=Qp1*(1-D/R)
NEW Qp1 = 12885 (cfs)

S T E P 2

Surcharge Height,

H = a * Qp1 ^ b
H = 11.66 (ft.)

Surcharge Volume,

ELV=ELV2 + H
ELV= 538.16 (ft.)

Volume = 287.758 (ac-ft)

STOR1 =Volume - Volume2

STOR1 = 247.717 (ac-ft)

STOR1 = .16 (in.)

MAIN

CORPS OF ENGINEERS — Job No. 1345-072-017 Sheet 6 of 24
LIMESTONE RESERVOIR — By T. OTOVA Date 2-3-81
FLOOD ROUTING CALCULATIONS — Ckd. ______ Rev. ______

Corresponding Discharge,

Qp2 = Qp1*(1-STOR1/R)
Qp2 = 12719 (cfs)

S T E P 3

Surcharge Height,

H = a * Qp2 ^ b
H = 11.56 (ft.)

Surcharge Volume,STOR2,

ELV = ELV2 + H
ELV = 538.06 (ft.)

Volume = 282.943 (ac-ft)

Diff.Volume = Volume - Volume2
Diff.Volume = 242.902 (ac-ft)
or
STOR2 = .16 (in.)

OLD STOR.AVE.= (STOR1 + STOR2) / 2
OLD STOR.AVE.= .16 (in.)

Qp3 =Qp1*(1 - OLD STO.AVE. / R

Qp3 = 12721 (cfs)

S T E P 4

Surcharge Height

H3 = a * Qp3 ^ b
H3 = 11.56 (ft.)

Diff.Volume,STOR3,

E1 = H3 + H2
E1 = 538.06 (cfs)
Volume = Exp((E1-m)/n)
Volume = 282.989 (ac-ft)

STOR3 = Volume - Volume2
STOR3 = 242.949 (ac-ft)
or
STOR3 = .16 (in.)

NEW STO.AVE.= (OLD STO.AVE. + STOR3) / 2
NEW STO.AVE.= .16 (in.)

Qp4 = Qp1 * (1 - NEW STO.AVE. / R)
Qp4 = 12722 (cfs)

Surcharge Height

H4 = a * Qp4 ^ b
H4 = 11.56 (ft.)

E2 = H4 + H2
E2 = 538.06 (ft.)

C H E K I N G :

E3 - E2 = 0 (ft.)

R E S U L T S :

AVERAGED DISCHARGE= 12721 (cfs)

WATER SURFACE ELEV.= 538.06 (ft.)

SURCHARGE HEIGHT = 11.56 (ft.)

CREST ELEV. OF THE DAM:
Ec= 534 (ft.)

VOLUME AT DAM CREST ELEV.:
Vc = 142.318 (ac-ft)

VOLUME AT MAX.WATER SURFACE ELEV

Vw = 283.001 (ac-ft)

MAIN

Client: CORPS OF ENGINEERS — Job No. 1345-072-017 — Sheet 7 of 24
Subject: LIMESTONE RESERVOIR — By T. OTOVA — Date 2-3-81
FLOOD ROUTING CALCULATIONS — Ckd. — Rev.

ESTIMATING

EFFECT OF SURCHARGE STORAGE

ON MAXIMUM PROBABLE DISCHARGES

These calculations are performed according to the Corps of Engineers Guidelines

LIMESTONE DAM

D A T A :

DRAINAGE AREA,
A= 27.9 (sq.mi.)

PEAK INFLOW,
Qp1= 6442 (cfs)

PRINCIPAL SPILLWAY CREST ELEV.,
ELV1= 526.5 (ft.)

EMERGENCY SPILLWAY CREST ELEV.,
ELV2= 526.5 (ft.)

Emergency Spillway Rating Curve is defined as ,

H = a * Q ^ b

a = .0212211655
b = .66667

The Capacity - Elv. curve is defined as,

Elv = m + n * Log(Volume)

m= 504.678
n= 5.914

TOTAL PMF RUNOFF,
R= 13 (in.)

CALCULATIONS:

STEP 1

Reduction of the Qp1 due to starting elevation at Principal Spillway crest elev.

Volume at 526.5 (ft.)

Volume1 =Exp((ELV1-m)/n)
Volume1 = 40.04 (ac-ft)

Volume at 526.5 (ft.)

Volume2 =Exp((ELV2-m)/n)
Volume2 = 40.04 (ac-ft)

Diff. of Volumes,

Diff.Volume = 0 (ac-ft)
or,
Diff.Volume, D= 0 (in.)

NEW Qp1=Qp1*(1-D/R)
NEW Qp1 = 6442 (cfs)

STEP 2

Surcharge Height,

H = a * Qp1 ^ b
H = 7.34 (ft.)

Surcharge Volume,

ELV=ELV2 + H
ELV= 533.84 (ft.)

Volume = 138.691 (ac-ft)

STOR1 =Volume - Volume2

STOR1 = 98.65 (ac-ft)
or,
STOR1 = .06 (in.)

Corresponding Discharge,

Qp2 = Qp1*(1-STOR1/R)
Qp2 = 6409 (cfs)

S T E P 3

Surcharge Height,

H = a * Qp2 ^ b
H = 7.32 (ft.)

Surcharge Volume,STOR2,

ELV = ELV2 + H
ELV = 533.82 (ft.)

Volume = 138.106 (ac-ft)

Diff.Volume = Volume - Volume2
Diff.Volume = 98.065 (ac-ft)
or
STOR2 = .06 (in.)

OLD STOR.AVE.= (STOR1 + STOR2) / 2
OLD STOR.AVE.= .06 (in.)

Qp3 =Qp1*(1 - OLD STO.AVE. / R)
Qp3 = 6409 (cfs)

S T E P 4

Surcharge Height

H3 = a * Qp3 ^ b
H3 = 7.32 (ft.)

Diff.Volume,STOR3,

E1 = H3 + H2
E1 = 533.82 (cfs)
Volume = Exp((E1-m)/n)
Volume = 138.107 (ac-ft)

STOR3 = Volume - Volume2
STOR3 = 98.067 (ac-ft)
or
STOR3 = .06 (in.)

NEW STO.AVE.= (OLD STO.AVE. + STOR3) / 2
NEW STO.AVE.= .06 (in.)

Qp4 = Qp1 * (1 - NEW STO.AVE. / R)
Qp4 = 6409 (cfs)

Surcharge Height

H4 = a * Qp4 ^ b
H4 = 7.32 (ft.)

E2 = H4 + H2
E2 = 533.82 (ft.)

C H E K I N G :

E3 - E2 = 0 (ft.)

R E S U L T S :

AVERAGED DISCHARGE= 6409 (cfs)

WATER SURFACE ELEV.= 533.82 (ft.)

SURCHARGE HEIGHT = 7.32 (ft.)

CREST ELEV. OF THE DAM:
Ec= 534 (ft.)

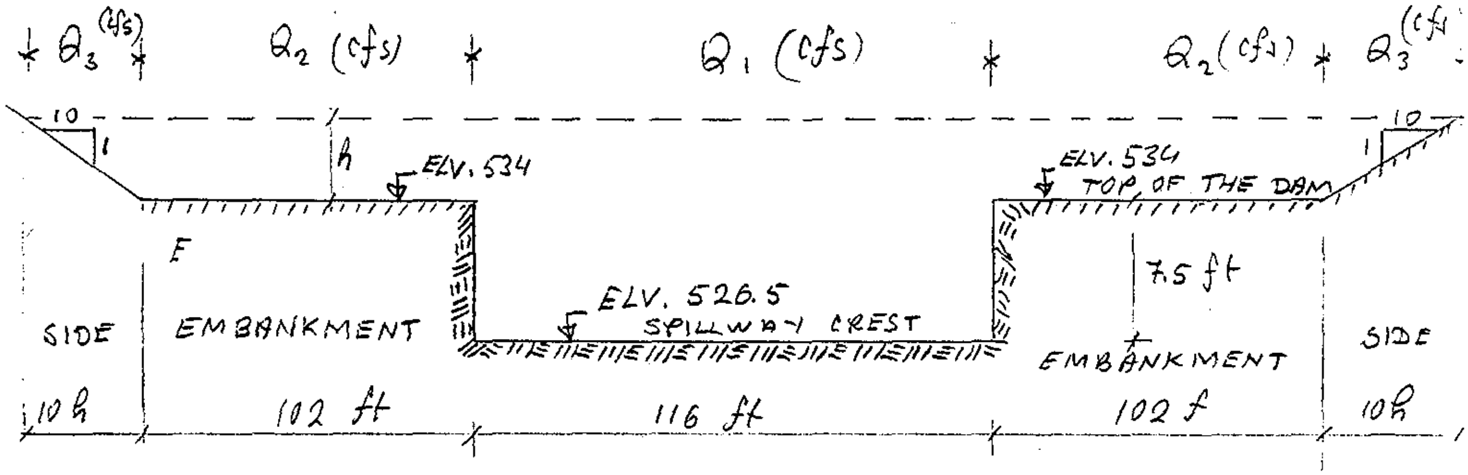
VOLUME AT DAM CREST ELEV :
Vc = 142.318 (ac-ft)

VOLUME AT MAX.WATER SURFACE ELEV

Vw = 138.108 (ac-ft)

Client: CORPS OF ENGINEERS — Job No. 1345-072 -017 — Sheet 9 of 24
Subject: LIMESTONE COMMUNITY RES. FLOOD ROUTING — By T. OTOVA — Date 2-4-81
Ckd. — Rev.

DETERMINATION OF THE OVERTOPPING



RATING FORMULA FOR THE SPILLWAY

$$Q_1 = C \times L \times H^{3/2}$$

$$Q_1 = 3.0 \times 116 \times H^{3/2} = 348\ H^{3/2} \ \ldots \quad (I)$$

or

$$H = \frac{1}{(348)^{2/3}} \times Q_1^{2/3}$$

$$H \simeq 0.0202122 \times Q_1^{(0.66667)} \ \ldots \quad (II)$$

RATING FORMULA FOR THE EMBANKMENTS

$$2 \times Q_2 = 2.9 \times 102 \times 2 \times h^{3/2}$$

$$2 \times Q_2 = 591.6\ h^{3/2} \ \ldots \quad (III)$$

MAIN

Client CORPS OF ENGINEERS — Job No. 1345-072-017 — Sheet 11 of 24

Subject LIMESTONE COMMUNITY RESERVOIR FLOOD ROUTING — By T. OTOVA — Date 2-4-81

Ckd. — Rev.

RATING FORMULA FOR THE SIDES

$$2\times Q_3 = \frac{1.49\times A\times R^{2/3}\times S^{1/2}}{n}\times 2$$

$$A = \frac{10\times h\cdot \times h}{2} = 5h^2$$

$$p = \left[h^2+(10h)^2\right]^{0.5} = h(1+10^2)^{0.5} \cong 10.05h$$

$$R = \frac{A}{p} = \frac{5h^2}{10.05h} = 0.4975\times h$$

$n = 0.07$

$S = 0.04$

} Both estimated

$$2\times Q_3 = \frac{1.49\times 5\times h^2\times(0.4975)^{2/3}\times h^{2/3}\times(0.04)^{0.5}}{0.07}\times 2$$

$$2\times Q_3 = \frac{1.49\times 5\times(0.4975)^{2/3}\times(0.04)^{0.5}\times 2}{0.07}\times h^{8/3}$$

$$2\times Q_3 \simeq 26.73\times h^{8/3} \quad \text{-------} \quad IV$$

FOR THE CASE OF OVERTOPPING THE RATING FORMULA:

$$Q = Q_1 + 2Q_2 + 2Q_3 \qquad H = h + 7.5$$

$$Q = 348\,(h+7.5)^{3/2} + 591.6\,h^{3/2} + 26.73\,h^{8/3}$$

MAIN

Client CORPS OF ENGINEERS Job No. 1345-072 -017 Sheet 11 of 24
Subject LIMESTONE COMMUNITY RESERVOIR By T. OTOVA Date 2-4-87
FLOOD ROUTING Ckd. Rev.

RATING TABLE FOR WATER LEVELS ABOVE THE DAM

HEIGHT	DISCHARGE
0	7147
.1	7309
.2	7488
.3	7679
.4	7879
.5	8087
.6	8304
.7	8528
.8	8759
.9	8997
1	9242
1.1	9493
1.2	9751
1.3	10015
1.4	10285
1.5	10561
1.6	10843
1.7	11132
1.8	11426
1.9	11726
2	12032
2.1	12344
2.2	12662
2.3	12986
2.4	13315
2.5	13650
2.6	13992
2.7	14339
2.8	14691
2.9	15050
3	15414
3.1	15785
3.2	16161
3.3	16543
3.4	16930
3.5	17324
3.6	17724
3.7	18129
3.8	18541
3.9	18958
4	19381

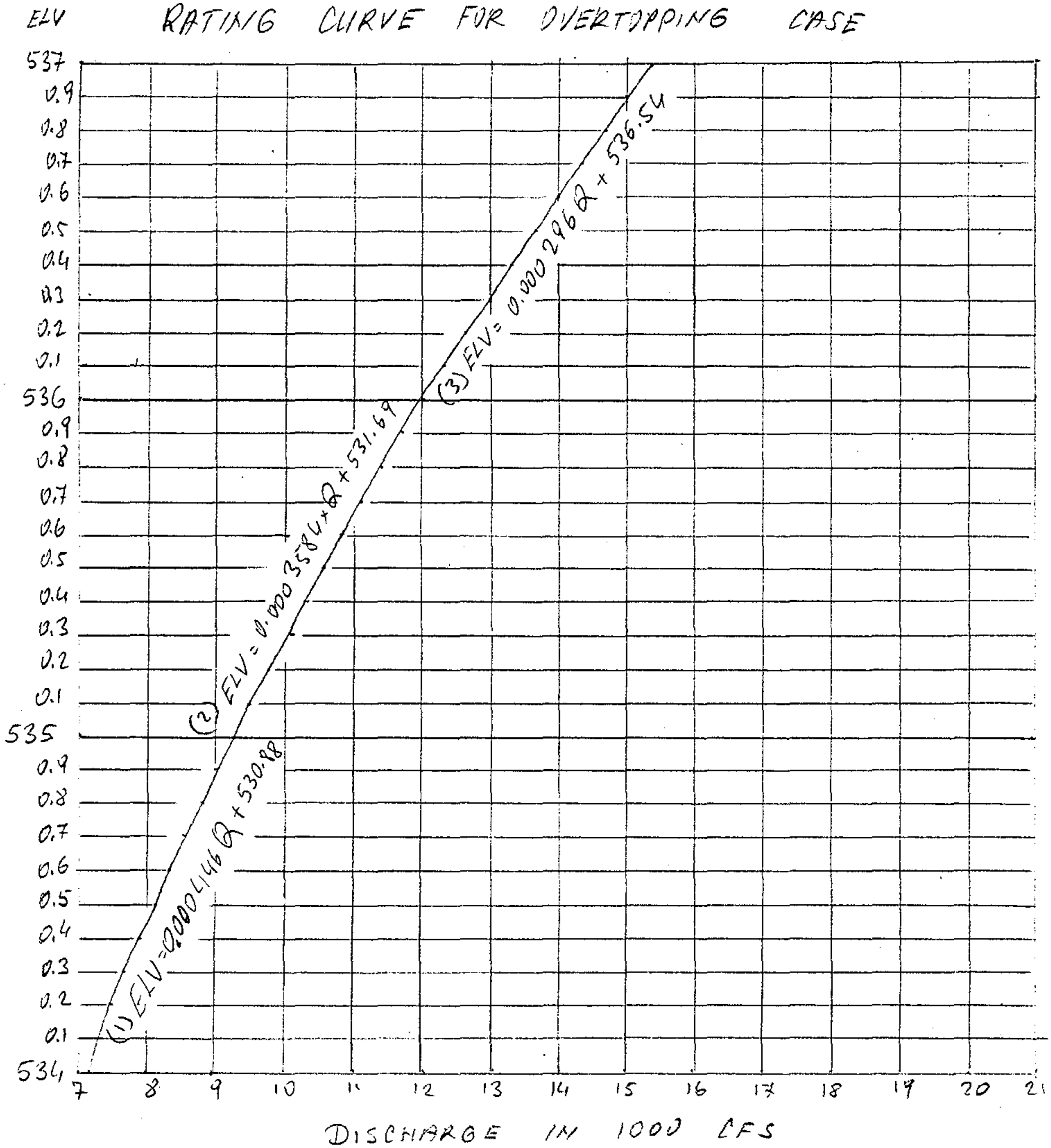
MAIN

Client: CORPS OF ENGINEERS — Job No. 1345-072-017 — Sheet 12 of 24

Subject: LIMESTONE COMMUNITY RESERVOIR FLOOD ROUTING — By T. OTOVA — Date 2-4-81

Ckd. ______ Rev. ______

RATING CURVE FOR OVERTOPPING CASE



OR,

1. $H = 0.000446\,Q - 3.12$
2. $H = 0.0003584\,Q - 2.31$
3. $H = 0.000296\,Q - 1.56$

H = Surcharge Height (ft)

ESTIMATING

EFFECT OF SURCHARGE STORAGE

ON MAXIMUM PROBABLE DISCHARGES

These calculations are performed according to the Corps of Engineers Guidelines

LIMESTONE DAM

D A T A :

DRAINAGE AREA,
A= 27.9 (sq.mi.)

PEAK INFLOW,
Qp1= 12885 (cfs)

THE CREST ELV.OF THE DAM = 534 (ft)

PRINCIPAL SPILLWAY CREST ELEV.,
ELV1= 526.5 (ft.)

EMERGENCY SPILLWAY CREST ELEV.,
ELV2= 526.5 (ft.)

Rating Curve is defined as ,

H = ai * Q ^ bi.....(III)for before overtopping
H ai * Q + bi.....(III)for after overtopping

a1 = .0202122
b1 = .66667

a2 = .000446
b2 = -3.12

a3 = .0003584
b3 = -2.31

a4 = .000296
b4 = -1.56

Rating Curve Changing Discharges
:
Q1= 7147
Q2= 9242
Q3= 12032

The Capacity - Elv. curve is defined as,

Elv = m + n * Log(Volume)

m= 504.678
n= 5.914

TOTAL PMF RUNOFF,
R= 13 (in.)

CALCULATIONS:

S T E P 1

Reduction of the Qp1 due to starting elevation at Principal Spillway crest elev.

Volume at 526.5 (ft.)

Volume1 =Exp((ELV1-m)/n
Volume1 = 40.04 (ac-ft)

Volume at 526.5 (ft.)

Volume2 =Exp((ELV2-m)/n)
Volume2 = 40.04 (ac-ft)

Diff. of Volumes,

Diff.Volume = 0 (ac-ft)
or,
Diff.Volume, D= 0 (in.)

NEW Qp1=Qp1*(1-D/R)
NEW Qp1 = 12885 (cfs)

lient CORPS OF ENGINEERS

ubject LIMESTONE RES. FLOOD ROUTING

S T E P 2

Surcharge Height,

From Formula (III)
H = 9.75 (ft.)

Surcharge Volume,

ELV=ELV2 + H
ELV= 536.25 (ft.)

Volume = 208.343 (ac-ft)

STOR1 =Volume - Volume2

STOR1 = 168.303 (ac-ft)
or,
STOR1 = .11 (in.)

Corresponding Discharge,

Qp2 = Qp1*(1-STOR1/R)
Qp2 = 12772 (cfs)

S T E P 3

Surcharge Height,

From Formula (III)
H = 9.72 (ft.)

Surcharge Volume,STOR2,

ELV = ELV2 + H
ELV = 536.22 (ft.)

Volume = 207.177 (ac-ft)

Diff.Volume = Volume - Volume2
Diff.Volume = 167.137 (ac-ft)
or
STOR2 = .11 (in.)

OLD STOR.AVE = (STOR1 + STOR2) / 2
OLD STOR.AVE.= .11 (in.)

Qp3 =Qp1*(1 - OLD STO.AVE. / R)
Qp3 = 12773 (cfs)

S T E P 4

Surcharge Height

From Formula (III)
H3 = 9.72 (ft.)

Diff.Volume,STOR3,

E1 = H3 + H2
E1 = 536.22 (cfs)
Volume = Exp((E1-m)/n)
Volume = 207.181 (ac-ft)

STOR3 = Volume - Volume2
STOR3 = 167.141 (ac-ft)
or
STOR3 = .11 (in.)

NEW STO.AVE.= (OLD STO.AVE. + STOR3) / 2
NEW STO.AVE.= .11 (in.)

Qp4 = Qp1 * (1 - NEW STO.AVE. / R)
Qp4 = 12773 (cfs)

Surcharge Height

From Formula (III)
H4 = 9.72 (ft.)

E2 = H4 + H2
E2 = 536.22 (ft.)

C H E K I N G :

E3 - E2 = 0 (ft.)

R E S U L T S :

AVERAGED DISCHARGE= 12773 (cfs)

WATER SURFACE ELEV.= 536.22 (ft.)

SURCHARGE HEIGHT = 9.72 (ft.)

CREST ELEV. OF THE DAM:
Ec= 534 (ft.)

VOLUME AT DAM CREST ELEV.:
Vc = 142.318 (ac-ft)

VOLUME AT MAX.WATER SURFACE ELEV
Vw = 207.182 (ac-ft)

Determination of the prefailure depths and the submergence of the spillway due to failure discharges.

LIMESTONE DAM
DAM FAILURE ANALYSES

These calculations are performed according to the RULE OF THUMB procedures of the Corps of Engineers

The breach discharge:
Qp1 = 8/27 * Wb * g^0.5 * Yo^3/2

Where,

Yo is the height of the breach (from river bed to the max. pool level)

Wb is 35% of the length of the dam, or Wb = .35 * Wd

g is the acceleration of the gravity (32.2 ft/sec^2)

Yo = 19 (ft)

Wd = 320 (ft)

Wb = 112 (ft)

From above equation,
Qp1 = 15595 (cfs)

The natural channel cross sections are simplyfied as triangular cross sections

The stage-discharge relationship becomes as,

h = [1.068 * n * Tan(a) * Q / Cos(a)^2/3 / S^.5]^3/8....(I)

Where,

Q = Discharge (cfs)
a = Side slope angle (deg)
S = Channel slope

The cross section Area:

A = h^2 / Tan(a) ....(II)

The Volume of the Reservoir,
V = 142 (ac-ft)
or,
V = 6185520 (cub-ft)

R E A C H (0) CALCULATIONS

Test flood discharge:
Qt = 7147 (cfs)

a = 4 (deg.)
S = .004
m = .07
L = 10 (ft)

From Formula (I),

Prefailure height,

h1 = 10.9 (ft)

From Formula (II) ,

A1 = 1715 (sq.ft.)

Q = Qp1 + Qt

From Formula (I),
Total Height,
h = 16.9 (ft)

From Formula (II),
Total Area,
A = 4087 (sq-ft)

Residual Area,
A2 = A - A1
A2 = 2371 (sq-ft)

Residual Volume,

V1 = L * A2

V1 = 23719 (cub-ft)

Qp2 = Qp1 * (1 - V1 / V)

Qp2 = 15535 (cfs)

From Formula (I),

Q=Qp2+Qt

Q = 22682 (cfs)

h = 16 (ft)

From Formula (II),

A = 4079 (ft)

Residual Area,

A2 = A - A1

A2 = 2363 (ft)

V2 = A2 * L

V2 = 23639 (cub-ft)

Vavg = (V1 + V2) / 2

Vavg = 23679 (cub-ft)

Qp2 = Qp1 * (1 - Vavg / V)

Qp2 = 15535 (cfs)

From Formula (I),

Q = Qp2 + Qt

h2 = 16.8 (ft)

RESULTS :

1.) Prefailure Height = 10.9 (ft)

2.) Postfailure Height = 16.8 (ft)

3.) Breach Discharge = 15535 (cfs)

4.) Reach Length = 10 (ft)

REACH (1) CALCULATIONS

Test flood discharge:
Qt = 7147 (cfs)

a = 4 (deg.)
S = .004
n = .07
L = 500 (ft)

From Formula (I),

Prefailure height,

h1 = 10.9 (ft)

From Formula (II) ,

A1 = 1715 (sq.ft.)

Q = Qp1 + Qt

From Formula (I),
Total Height,
h = 16.8 (ft)

From Formula (II),
Total Area,
A = 4079 (sq-ft)

Residual Area,
A2 = A - A1
A2 = 2363 (sq-ft)

Residual Volume,

V1 = L * A2

V1 = 1181972 (cub-ft)

Qp2 = Qp1 * (1 - V1 / V)

Qp2 = 12567 (cfs)

From Formula (I),

Q=Qp2+Qt

Q = 19714 (cfs)

h = 16 (ft)

From Formula (II),

A = 3672 (ft)

Residual Area,

A2 = A - A1

A2 = 1956 (ft)

V2 = A2 * L

V2 = 978277 (cub-ft)

Vavg = (V1 + V2) / 2

Vavg = 1080124 (cub-ft)

Qp2 = Qp1 * (1 - Vavg / V)

Qp2 = 12823 (cfs)

From Formula (I),

Q = Qp2 + Qt

h2 = 16.1 (ft)

RESULTS :

1.) Prefailure Height = 10.9 (ft)

2.) Postfailure Height = 16.1 (ft)

3.) Breach Discharge = 12823 (cfs)

4.) Reach Length = 500 (ft)

R E A C H (2) CALCULATIONS

Test flood discharge:
Qt = 7147 (cfs)

a = 4 (deg.)
S = .004
n = .07
L = 500 (ft)

From Formula (I),

Prefailure height,

h1 = 10.9 (ft)

From Formula (II) ,

A1 = 1715 (sq.ft.)

Q = Qp1 + Qt

From Formula (I),
Total Height,
h = 16.1 (ft)

From Formula (II),
Total Area,
A = 3707 (sq-ft)

Residual Area,
A2 = A - A1
A2 = 1992 (sq-ft)

Residual Volume,

V1 = L * A2

V1 = 996117 (cub-ft)

Qp2 = Qp1 * (1 - V1 / V)

Qp2 = 10757 (cfs)

From Formula (I),

Q=Qp2+Qt

Q = 17904 (cfs)

h = 15 (ft)

From Formula (II),

A = 3416 (ft)

Residual Area,

A2 = A - A1

A2 = 1700 (ft)

V2 = A2 * L

V2 = 850390 (cub-ft)

Vave = (V1 + V2) / 2

Vave = 923253 (cub-ft)

Qp2 = Qp1 * (1 - Vave / V)

Qp2 = 10909 (cfs)

From Formula (I),

Q = Qp2 + Qt

h2 = 15.5 (ft)

RESULTS :

1.) Prefailure Height = 10.9 (ft)

2.) Postfailure Height = 15.5 (ft)

3.) Breach Discharge = 10909 (cfs)

4.) Reach Length = 500 (ft)

Client CORPS OF ENGINEERS Job No. 1345-072 Sheet 19 of 24
Subject LIMESTONE DAM FAILURE ANALYSES By T. OTOVA Date 2-5-81
Ckd. Rev.

Determination of the downstream flood levels by considering the reduction of the spillway discharge due to submergence effects.

"Ref. Desing of Small Dams, p.p. 380 figure 252, 1977"

$He = 7.5$ ft $h_d = 19 - 16.8 = 2.2$ ft. $h_d / He = 0.29$

$\frac{h_d + He}{He} = \frac{19}{7.5} = 2.53$

Reduction = 6 percent

$Q_E = 7147 \times 0.94 = 6718$ cfs.

LIMESTONE DAM
DAM FAILURE ANALYSES

These calculations are performed according to the RULE OF THUMB procedures of the Corps of Engineers

The breach discharge:
Qp1 = 8/27 * Wb * g^0.5 * Yo^3/2

Where,

Yo is the height of the breach (from river bed to the max. pool level)

Wb is 35% of the length of the dam, or Wb = .35 * Wd

g is the acceleration of the gravity (32.2 ft/sec^2)

Yo = 19 (ft)

Wd = 320 (ft)

Wb = 112 (ft)

From above equation,
Qp1 = 15595 (cfs)

The natural channel cross sections are simplyfied as triangular cross sections

The stage-discharge relationship becomes as,

h = [1.068 * n * Tan(a) * Q / Cos(a)^2/3 / S^.5]^3/8....(I)

Where,

Q = Discharge (cfs)
a = Side slope angle (deg)
S = Channel slope

The cross section Area:

A = h^2 / Tan(a) ..(II)

The Volume of the Reservoir,
V = 142 (ac-ft)
or,
V = 6185520 (cub-ft)

R E A C H (1) CALCULATIONS

Test flood discharge:
Qt = 6718 (cfs)

a = 4 (deg.)
S = .004
n = .07
L = 500 (ft)

From Formula (I),

Prefailure height,

h1 = 10.7 (ft)

From Formula (II) ,

A1 = 1637 (sq.ft.)

Q = Qp1 + Qt

From Formula (I),
Total Height,
h = 16.7 (ft)

From Formula (II),
Total Area,
A = 4029 (sq-ft)

Residual Area,
A2 = A - A1
A2 = 2391 (sq-ft)

Residual Volume,

V1 = L * A2

V1 = 1195930 (cub-ft)

Qp2 = Qp1 * (1 - V1 / V)

Qp2 = 12580 (cfs)

From Formula (I),

Q=Qp2+Qt

Q = 19298 (cfs)

h = 15 (ft)

From Formula (II),

A = 3613 (ft)

Residual Area,

A2 = A - A1

A2 = 1976 (ft)

V2 = A2 * L

V2 = 988064 (cub-ft)

Vavg = (V1 + V2) / 2

Vavg = 1091997 (cub-ft)

Qp2 = Qp1 * (1 - Vavg / V)

Qp2 = 12842 (cfs)

From Formula (I),

Q = Qp2 + Qt

h2 = 15.9 (ft)

RESULTS :

1.) Prefailure Height = 10.7 (ft)

2.) Postfailure Height = 15.9 (ft)

3.) Breach Discharge = 12842 (cfs)

4.) Reach Length = 500 (ft)

MAIN

Client CORPS OF ENGINEERS | Job No. 1345-072 -017 | Sheet 21 of 24
Subject LIMESTONE DAM | By T.O.TOVIA | Date 2-5-81
FAILURE ANALYSES | Ckd. | Rev.

REACH (2) CALCULATIONS

Test flood discharge:
Qt = 6718 (cfs)

a = 4 (deg.)
S = .004
n = .07
L = 500 (ft)

From Formula (I),

Prefailure height,

h1 = 10.7 (ft)

From Formula (II),

A1 = 1637 (sq.ft.)

Q = Qp1 + Qt

From Formula (I),
Total Height,
h = 15.9 (ft)

From Formula (II),
Total Area,
A = 3650 (sq-ft)

Residual Area,
A2 = A - A1
A2 = 2012 (sq-ft)

Residual Volume,

V1 = L * A2

V1 = 1006436 (cub-ft)

Qp2 = Qp1 * (1 - V1 / V)

Qp2 = 10752 (cfs)

From Formula (I),

Q=Qp2+Qt

Q = 17470 (cfs)

h = 15 (ft)

From Formula (II),

A = 3354 (ft)

Residual Area,

A2 = A - A1

A2 = 1716 (ft)

V2 = A2 * L

V2 = 858142 (cub-ft)

Vave = (V1 + V2) / 2

Vave = 932289 (cub-ft)

Qp2 = Qp1 * (1 - Vave / V)

Qp2 = 10906 (cfs)

From Formula (I),

Q = Qp2 + Qt

h2 = 15.3 (ft)

RESULTS :

1.) Prefailure Height = 10.7 (ft)

2.) Postfailure Height = 15.3 (ft)

3.) Breach Discharge = 10906 (cfs)

4.) Reach Length = 500 (ft)

MAIN

Client: CORPS OF ENGINEERS | Job No. 1345-072 / .017 | Sheet 22 of 24
Subject: LIMESTONE DAM | By T. OTOVA | Date 2-5-81
FAILURE ANALYSES | Ckd. | Rev.

Determination of the downstream flood levels due to failure of the dam in dry conditions ($Q_{test} = 0$ cfs)

LIMESTONE DAM
DAM FAILURE ANALYSES

These calculations are performed
 according to the RULE OF THUMB
procedures of the
Corps of Engineers

The breach discharge:
Qp1 = 8/27 * Wb * g^0.5 * Yo^3/2

Where,

Yo is the height of the breach (
from river bed to the max. pool
level)

Wb is 35% of the length of the d
am, or Wb = .35 * Wd

g is the acceleration of the gra
vity (32.2 ft/sec^2)

Yo = 11.5 (ft)

Wd = 170 (ft)

Wb = 59 (ft)

From above equation,
Qp1 = 3901 (cfs)

The natural channel cross sectio
ns are simplyfied as triangular
cross sections

The stage-discharge relationship
 becomes as,

h = [1.068 * n * Tan(a) * Q / C
os(a)^2/3 / S^.5]^3/8.....(I)

Where,

Q = Discharge (cfs)
a = Side slope angle (deg)
S = Channel slope

The cross section Area:

A = h^2 / Tan(a) ....(II)

The Volume of the Reservoir,
V = 40 (ac-ft)
or,
V = 1742400 (cub-ft)

Client CORPS OF ENGINEERS Job No. 1345-072-012 Sheet 23 of 24
Subject LIMESTONE DAM By T. OTUYA Date 2-5-81
FAILURE ANALYSES Ckd. Rev.

R E A C H (1) CALCULATIONS

Test flood discharge:
Qt = 0 (cfs)

a = 4 (deg.)
S = .004
n = .07
L = 500 (ft)

From Formula (I),

Prefailure height,

h1 = 0 (ft)

From Formula (II) ,

A1 = 0 (sq.ft.)

Q = Qp1 + Qt

From Formula (I),
Total Height,
h = 8.7 (ft)

From Formula (II),
Total Area,
A = 1089 (sq-ft)

Residual Area,
A2 = A - A1
A2 = 1089 (sq-ft)

Residual Volume,

V1 = L * A2

V1 = 544793 (cub-ft)

Qp2 = Qp1 * (1 - V1 / V)

Qp2 = 2681 (cfs)

From Formula (I),

Q=Qp2+Qt

Q = 2681 (cfs)

h = 7 (ft)

From Formula (II),

A = 822 (ft)

Residual Area,

A2 = A - A1

A2 = 822 (ft)

V2 = A2 * L

V2 = 411250 (cub-ft)

Vavg = (V1 + V2) / 2

Vavg = 478021 (cub-ft)

Qp2 = Qp1 * (1 - Vavg / V)

Qp2 = 2831 (cfs)

From Formula (I),

Q = Qp2 + Qt

h2 = 7.7 (ft)

RESULTS :

1.) Prefailure Height = 0 (ft)

2.) Postfailure Height = 7.7 (ft)

3.) Breach Discharge = 2831 (cfs)

4.) Reach Length = 500 (ft)

MAIN

Client CORPS OF ENGINEERS Job No. 1345-077 -017 Sheet 24 of 24
Subject LIMESTONE DAM By T. OTOVA Date 2-5-81
FAILURE ANALYSES Ckd. Rev.

R E A C H (2) CALCULATIONS

Test flood discharge:
Qt = 0 (cfs)

s = 4 (deg.)
S = .004
n = 07
L = 500 (ft)

From Formula (I),

Prefailure height,

h1 = 0 (ft)

From Formula (II) ,

A1 = 0 (sq.ft.)

Q = Qp1 + Qt

From Formula (I),
Total Height,
h = 7.7 (ft)

From Formula (II),
Total Area,
A = 856 (sq-ft)

Residual Area,
A2 = A - A1
A2 = 856 (sq-ft)

Residual Volume,

V1 = L * A2

V1 = 428329 (cub-ft)

Qp2 = Qp1 * (1 - V1 / V)

Qp2 = 2135 (cfs)

From Formula (I),

Q=Qp2+Qt

Q = 2135 (cfs)

h = 6 (ft)

From Formula (II),

A = 693 (ft)

Residual Area,

A2 = A - A1

A2 = 693 (ft)

V2 = A2 * L

V2 = 346642 (cub-ft)

Vave = (V1 + V2) / 2

Vave = 387486 (cub-ft)

Qp2 = Qp1 * (1 - Vave / V)

Qp2 = 2201 (cfs)

From Formula (I),

Q = Qp2 + Qt

h2 = 7 (ft)

RESULTS :

1.) Prefailure Height = 0 (ft)

2.) Postfailure Height = 7 (ft)

3.) Breach Discharge = 2201 (cfs)

4.) Reach Length = 500 (ft)

APPENDIX E

"NATIONAL INVENTURY OF DAMS IN THE UNITED STATES"

NOT AVAILABLE AT THIS TIME